PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION

POST OCT 1 1921

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

Engineering Library

VOL. CXII.—No. 2909.] *LONDON: FRIDAY, SEPTEMBER* 30, 1921. [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

Aveling & Porter, Ltd.,
ROCHESTER.
9037
Steam Road Rollers & Tractors.

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, pages 31 and 79, last week.
PATENT WATER TUBE BOILERS, AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2179

John H. Wilson & Co., Ltd., Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28.

Locomotive Shunting Cranes

Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY.
9364
LISTS OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W. 1.

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON and BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C. Od3382

Craig & Donald Ltd., Machine
TOOL MAKERS, JOHNSTONE, near Glasgow.
For class of Machine Tools see our Illustrated Advertisement every alternate week. 1358

CHANTIERS & ATELIERS
Augustin Normand
67, rue de Perrey—LE HAVRE (France).
3890
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Electric Lifts
(UP TO 35 TONS.)
S. H. HEYWOOD & CO., LTD., REDDISH. 9026

Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS.
9193
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH

Brett's Patent Lifter Co. LIMITED.
Hammers, Presses, Furnaces,
COVENTRY. 610

Bever, Dorling & Co., Ltd.,
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 9109

Telegrams—"Cylinders," Birmingham.
Weldless-Steel Tubes
for Water-tube Boilers, Superheaters, Shafting, Hydraulic Work Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. O8179

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS, GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 9563
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17, Sept. 23. 9108

Electric Cranes.
9026
S. H. HEYWOOD & CO., LTD., REDDISH.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 9074

A Time Recorder, as New,
guaranteed, latest model. WHAT OFFERS? —A. G. PELLEY, 149, Farringdon Road, E.C. 1. F 599

S. Sokal, CHARTERED PATENT AGENT.
1, Great James Street, Bedford Row, London, W.C.1. T.N. 4518 Museum. 9675

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9105

Machining Work Wanted.—
Engineering Works with modern plant and own railway siddings WANT REPETITION WORK. Centre lathe work (up to 16 in. centres), boring, drilling, shaping, plate working. Keen prices on receipt of sample or blue print.
Machined Castings of finest quality in iron or gunmetal to customers' own patterns or drawings.
Open to manufacture any special machinery or small parts.
SALTERNS LTD., Engineers, Parkstone, Dorset. R 772

"Spencer-Hopwood" Patent Boilers. *See page* 81, Sept. 23.
Sole Makers:
SPENCER-BONECOURT, LTD., 9263
Parliament Mansions, Victoria St., London, S.W.
GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED.

Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 15. 8902

Castings (Iron). — Orders
WANTED for any weight and size (Yorkshire District) machined if necessary.—Address, 9062, Offices of ENGINEERING.

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794

Phone—Holb. 541. Tele—Andrubo, Holb., London.
Andrews & Beaumont,
(Ewart S. Andrews, B.Sc.; J. Harold Beaumont)
PATENT AGENTS,
29, Southampton Buildings, London, W.C. 2. 9308

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
The Scottish Tube Co., Ltd,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 87.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } HOW'S PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

Tubes and Fittings,
IRON AND STEEL.
Stewarts and Lloyd's, Ltd.,
41, OSWALD ST., GLASGOW.
BROAD STREET CHAMBERS, BIRMINGHAM, and LONDON OFFICE—
WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—167, UPR. THAMES ST., E.C.
LIVERPOOL WAREHOUSE—63, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—133, BUTE ST.
BIRMINGHAM WAREHOUSE—NILE STREET, SHEEPSCOTE STREET.
See Advertisement page 26. 9091

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 9604

Locomotive Traversers
(ELECTRIC).
9026
S. H. HEYWOOD & CO., LTD., REDDISH.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 9241

See's Patent Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4535

Diesel Engines, Six Cylinder,
two and four stroke, 850, 1000, 1200 H.P. Excellent condition. Dynamos for above 250 or 500 Volts, D.C. Immediate delivery and low price.
Also 2-500 Kw. PARSONS TURBINE SETS 250 or 500 Volts, D.C., with Condenser and spare armature.
ELECTRICALLY DRIVEN AIR COMPRESSORS, 250 Volts, D.C. Pressures 1500 to 3000 lbs. per square inch.
JENNINGS,
West Wall, Newcastle-on-Tyne. 8888

Chimney Shafts
DESIGNED, ERECTED or REPAIRED by Chimney Experts.
Enquiries invited. Write, phone, call or wire—
CUSTODIS LTD.,
119, Victoria Street, London, S.W. 1.
Telephone:—779 Victoria. 9548
Telegrams:—"Custodomus-Sowest, London."

Crane and Sling Chains up to
4 in. dia. iron, also Electric Welded Chains, Blocks and Crab Winches for chains or ropes, Screw Jacks, Patent two-speed Hydraulic Jacks, Hooks, Swivels, Shackles, General Smiths' work. Estd. 1841. —FILLOWS BROS., LTD., Cradley Heath, Staffs. 9158

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Od 3547
Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W.1.

Yarrow Patent
Water-Tube Boilers.
9364
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od3383

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 67, Sept. 23. 2402

Taylor & Challen
Presses
9196
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full Page Advertisement page 74, Sept. 16

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, Dumbarton. 9318
See Full Page Advt., page 76, Sept. 16.

Machinery Inspections. —
Power Plant a Speciality. Inspections carried out; Tests attended; Reports made; Overhauls and Alterations supervised. Pipes and Metals inspected.—H. BROWN, A.M.I. Mech. E., 51, Charles St., Cardiff. Telegrams: "Emergency," Cardiff. Telephone No.: 3490 Cardiff. 9035

WAYGOOD-OTIS LIFTS. 9453
84 & 85, FETTER LANE, LONDON, E.C. 4.
62 & 63, LIONEL STREET, BIRMINGHAM.
and Principal Provincial Cities.

Electric Transporters.
S. H. HEYWOOD & CO., LTD., REDDISH. 9026

GRAPHITED OIL. GRAPHITED WATER.
"OILDAG" (Reg.) BRAND. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE.
"GREDAG"
9505
E. G. Acheson Ltd.,
Dept. H. (Sole Manufacturers.) Works:
40, WOOD ST., S.W. 1. PLYMOUTH.

See Advt. page 92, Sept. 23
Steam & Pneumatic Power Hammers
Drop Stamping Plant
B. & S. Massey, Ltd., 9140 MANCHESTER.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by SIR WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

The Bucyrus Company,

EXCAVATING AND MINING MACHINERY MAKERS

of South Milwaukee, Wisconsin, U.S.A., and formerly represented in the British Isles by Messrs. G. F. West & Co., wish to announce that they have now Opened their Own Office at

19, IDDESLEIGH HOUSE, CAXTON STREET, WESTMINSTER,

and henceforth All Communications for them should be so addressed.

9741

University of Manchester.

EVENING CLASSES in Civil and Mechanical Engineering. These classes will meet on MONDAYS, at Seven and Eight p.m. respectively. First Lecture, October 10th. Fee 10s. 6d. each class. For further particulars, apply to the Internal Registrar.

S. CHAFFERS, Bursar. S 174

CITY OF CARDIFF EDUCATION COMMITTEE.

The Technical College.

Principal — CHARLES COLES, B.Sc. (Lond.).

DEPARTMENT OF ENGINEERING.

Head of Department — A. W. LOVERIDGE, B.Sc. (Eng.), A.R.C.Sc.

The following Courses have been arranged for Engineering Students:—

A Three Years' Course in Mechanical and Marine Engineering, jointly with the University College of South Wales, Monmouthshire.

A Two Years' Course for apprentices and others with facilities for practical experience in the Summer Term.

These courses are suitable for students preparing for degrees in Engineering or for the examinations of the Engineering Societies.

Special Courses are also arranged for Marine Engineers preparing for the examinations of the Board of Trade.

Further information in regard to Full-time and Part-time Courses, fees, &c., may be obtained on application to the Principal.

JOHN J. JACKSON, B.A., Director of Education.

City Hall, Cardiff. S 58

ENGINEERING AND TECHNICAL OPTICS.

Northampton Polytechnic Institute.

ST. JOHN STREET, LONDON, E.C. 1.

ENGINEERING DAY COLLEGE.

Full-Time Day Courses in the Theory and Practice of Civil, Mechanical, and Electrical Engineering. The Courses in Civil and Mechanical Engineering include specialization in Automobile and Aeronautical Engineering, and those in Electrical Engineering include specialization in RADIO-TELEGRAPHY.

A SPECIAL ENTRANCE EXAMINATION is held at the end of September before the commencement of each session. The Courses include periods spent in commercial workshops and extend over four years. They also prepare for the Degree of B.Sc. in Engineering at the University of London. Fees £13 or £13 per annum.

THREE ENTRANCE SCHOLARSHIPS of the value of £62 each for the complete course will be offered for competition at the annual entrance examination in September.

OPTICAL ENGINEERING AND TECHNICAL OPTICS.

Full and Part-time Courses in this important department of Applied Science are given in specially equipped laboratories and lecture rooms. The annual entrance examination is held at the end of September.

EVENING TECHNICAL COURSES in all branches of Mechanical and Electrical Engineering commence on Monday, September 26th, 1921.

The Laboratories, both Mechanical and Electrical, are well equipped with modern apparatus which, on the Mechanical side, provides for specialization in Automobile and Aeronautical Engineering and, on the Electrical side, for specialization in Alternate and Continuous Current Work, in Radio-Telegraphy and Telephonym and in Electrical Testing.

Particulars as to fees, dates, etc., and all information respecting the work of the Institute can be obtained at the Institute or on application to:

R. MULLINEUX WALMSLEY, D.Sc., Principal. S 25

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to MR. TREVOR W. PHILLIPS, B.Sc. (Hons.), Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 58, South John Street, Liverpool. 9296

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 9649

Inst.C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience. Address, 7434, Offices of ENGINEERING.

Penningtons, University

TUTORS, 254, Oxford Road, Manchester. Estab. 1876. Postal courses for all Engineering Exams. Enrol now for I.C.E. and I.M.E. Courses. 100 per cent. passes last Exams. 8901

TENDERS.

EAST INDIAN RAILWAY.

The East Indian Railway Company is prepared to receive

Tenders for the Supply and

DELIVERY of:—

BARE COPPER STRIP AND WIRE, as per Specifications to be seen at the Company's Offices.

Tenders are to be sent to the undersigned, marked "Tender for Copper Wire," not later than Eleven o'clock a.m., on Wednesday, the 5th day of October proximo.

The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any tender.

For each specification a fee of £1 1s. is charged, which cannot under any circumstances be returned.

By Order,
G. H. LILLIE,
Secretary.

Nicholas Lane, London, E.C. 4.
24th August, 1921. S 142

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to noon on Wednesday, 19th October,

Tenders for the Supply of

1. RED AND WHITE LEAD.
2. CANVAS, BUNTING, Etc.
3. DISINFECTANT FLUID.
4. LAMPS, LAMP FITTINGS AND MISCELLANEOUS GLASS.
5. PAINTS, Etc.

Tenders must be made on forms, copies of which, with specification can be obtained at these Offices on payment as follows:—

For Nos. 1 and 2, 20/- each, for Nos. 3 and 4, 10/- each and for No. 5, 5/- each (which will not be returned). The Directors do not bind themselves to accept the lowest or any tender.

S. G. S. YOUNG, Secretary.

Offices: The White Mansion, 91, Petty France, Westminster, S.W. 1. S 194

26th Sept. 1921.

PORT OF BRISTOL.

STEEL BUILT OVERHEAD GALLERY FOR COLD STORES, ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee are prepared to receive

Tenders for the Construction,

etc., of an OVERHEAD GALLERY for use in connection with the Royal Edward Cold Stores, Avonmouth Dock.

On and after Tuesday, the 4th prox., copies of the Specification and Contract Drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £2 has been paid to the Bristol Docks Committee, 19, Queen Square, Bristol, to whom all cheques must be made payable, The deposit of £2 will be returned to *bona fide* tenderers after receipt of Tenders with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope endorsed "Tender for Overhead Gallery" and addressed to the General Manager and Secretary of the Docks Committee, Dock Office, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before Ten a.m. on Tuesday, the 18th day of October, 1921.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE, Engineer.

Engineer's Office, Avonmouth Dock, 27th Sept. 1921. S 190

BIDEFORD URBAN DISTRICT COUNCIL WATERWORKS.

TO CONTRACTORS.

The Bideford Urban District Council are prepared to receive

Tenders for the Following

WORKS:—

1. MASONRY DAM for a reservoir to contain 27,000,000 gallons.
2. THREE SAND FILTERS, each 30 ft. by 40 ft., to filter 56,000 gallons per 24 hours; and CLEAR WATER WELL.
3. 6 INCH CAST IRON MAIN, 900 yards in length.
4. Existing HIGH LEVEL TANK increased in capacity from 75,000 to 150,000 gallons, and a
5. SUCTION GAS PUMPING INSTALLATION, capable of pumping 14,000 gallons per hour against a head of 240 feet.

The site of the proposed reservoir is about ¾ mile from Bideford.

The plans can be seen and copies of the Specification and Bill of Quantities obtained at the offices of the Consulting Engineers, Messrs. ST. GEORGE-MOORE and LA TROBE-BATEMAN, M.M.Inst.C.E., 91, Victoria Street, Westminster, S.W. 1, or H. B. L. HOOKWAY, Esq., Borough Surveyor, Bideford, on payment of a deposit of £5, which will be returned on receipt of a *bona fide* Tender.

Tenders in sealed envelopes, endorsed "Bideford Waterworks," and addressed to me, must be received by Three p.m. on the 19th October, 1921.

The Council do not bind themselves to accept the lowest or any Tender, and reserve the right to divide the contract.

W. B. SELDON, Town Clerk.

Bideford, September, 1921. S 143

H.E.H. THE NIZAM'S GUARANTEED STATE RAILWAYS COMPANY, LIMITED.

The Board of Directors of H.E.H. The Nizam's Guaranteed State Railways Company, Limited, are prepared to receive—

Tenders for the Supply of :—

480 STEEL TYRES for Carriages and Wagons.

For each copy of the Specification a fee of Ten Shillings will be charged, which is not returnable. Tenders, enclosed in sealed envelopes addressed to the Chairman and Directors and endorsed "Tender for Steel Tyres," must be delivered at the Company's Offices not later than Twelve noon on 13th October, 1921. The Directors do not bind themselves to accept the lowest or any Tender, and reserve the right to divide the order.

By Order of the Board, F. ADAMS, Secretary.

Winchester House, 80, Old Broad Street, E.C. 2.
27th September, 1921. S 186

APPOINTMENTS OPEN.

LEIGH MUNICIPAL TECHNICAL SCHOOL.

The Committee require the

Services of a Teacher of Coal

Mine Working and Mining Law—one evening or Saturday afternoon each week. Applications should be sent to the undersigned as early as possible.

JAMES WARD, Director of Education.

Education Offices, Town Hall, Leigh. September 26th, 1921. S 166

RESEARCH DEPARTMENT, ROYAL ARSENAL, WOOLWICH.

DIRECTORATE OF METALLURGICAL RESEARCH.

Required, Temporary

HEAD of BRANCH for not less than one year.

Candidates should possess good academic qualifications and have specialised in non-ferreous and physical metallurgy.

Initial salary £600 and bonus (total emoluments at present approximately £963).

Applications in writing with copies of testimonials, and reference to any published work should be made to the CHIEF SUPERINTENDENT, RESEARCH DEPARTMENT, ROYAL ARSENAL, WOOLWICH, S.E., from whom the Conditions of Employment may be obtained. S 154

STAFFORDSHIRE EDUCATION COMMITTEE.

COUNTY TECHNICAL COLLEGE, WEDNESBURY.

Applications are Invited for

the POST of ASSISTANT LECTURER IN METALLURGY at the above College. The candidate should have had good works and teaching experience, and a University degree is desirable.

Salary according to the Burnham scale.

Further particulars and forms of application, which should be returned on or before 13th October, 1921, may be obtained from the undersigned on receipt of a stamped addressed envelope.

GRAHAM BALFOUR, Director of Education.

County Education Offices, Stafford. September, 1921. S 105

ARTILLERY COLLEGE, WOOLWICH.

DEPARTMENT OF MECHANICAL AND ELECTRICAL ENGINEERING.

Professor:—
MR. J. J. GUEST.

Applications are Invited

for the POST of:—

JUNIOR LECTURER.

Salary £400 p.a. to £500 p.a.

DEMONSTRATOR.

Salary £300 p.a. to £400 p.a.

in the Mechanical Engineering Section.

Posts pensionable under the Federated Superannuation Scheme for Universities.

The Junior Lecturer preferably should have had experience in Internal Combustion Engine work.

Applications should be made in writing to:—

THE COMMANDANT, Artillery College, Red Barracks, Woolwich, S.E. 18,

from whom further particulars may be obtained. S 160

GLAMORGAN EDUCATION COMMITTEE.

APPOINTMENT OF LECTURER IN MECHANICAL ENGINEERING.

The Committee propose to

Appoint a Travelling Lecturer

in Mechanical Engineering. Applicants must possess special qualifications for teaching Engineering and Allied Subjects. Successful candidates must devote their whole time to the duties and reside where directed by the Committee, and will be required to commence duties as early as possible in November.

Salary to be in accordance with the Burnham Scale for Technical Teachers, as finally approved by the Board of Education, with expenses according to Scale.

In assessing the commencing salary, regard may be had to previous full-time teaching experience in a recognised efficient school subject in the case of service under other Authorities to a limit of ten years, and suitable experience in Works may also be taken into consideration. Canvassing will disqualify.

Applications, on forms which will be supplied on receipt of a stamped addressed foolscap envelope, must reach the CHIEF EDUCATION OFFICIAL, County Hall, Cardiff, by the 12th October, 1921. S 188

PORTSMOUTH MUNICIPAL COLLEGE.

MECHANICAL AND CIVIL ENGINEERING DEPARTMENT.

Principal:
OLIVER FREEMAN, Wh.Sc., A.R.C.S., B.Sc.
Head of Department:
R. C. PRESCOTT, M.Sc. (Tech.), A.M.S.T.

Applications are Invited for

the APPOINTMENT of a LECTURER in MECHANICAL ENGINEERING. Salary according to the Burnham Committee's Scale. Further particulars and Forms of Application may be obtained from the undersigned, to whom applications should be returned at once, accompanied by copies only of not more than three recent testimonials.

H. B. CURTIS, Secretary.

Offices for Higher Education, The Municipal College, Portsmouth. S 196

Locomotive Superintendent

REQUIRED for the Railway Department by the GOVERNMENT OF MAURITIUS, for three years' service with probable permanency. Salary 7500 rupees a year. Quarters not provided. Free passages. Candidates under 35, with a knowledge of the French Language, must have served an apprenticeship in the Locomotive Department of a British Railway and have experience in the Running Department in responsible charge. Application should be made at once in writing, giving age and brief details of experience to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/11063. S 159

ASSISTANT LOCOMOTIVE SUPERINTENDENTS, INDIAN STATE RAILWAYS.

THE SECRETARY OF STATE FOR INDIA, will, in 1921, with the advice of a Selection Committee, make

Three Appointments of

ASSISTANT LOCOMOTIVE SUPERINTENDENTS for service on Indian State Railways, if so many suitable candidates present themselves.

Candidates must be British subjects not more than 27 years of age, and must be of good moral character and sound physique.

They must have had a good general and technical education, followed by at least three years' training in the locomotive workshops of a British Railway Company, or a locomotive builder of repute, and should have had six months' training in the running sheds and firing. A knowledge of applied mechanics and the nature and composition of all materials used in shops is essential, and applicants should be able to design and to calculate the stresses on the parts of the machines. Some drawing office experience is also desirable.

Persons whose practical experience falls short of three years, but who have served in His Majesty's Forces during the war will be eligible as candidates; but, if selected, will be required before appointment to complete satisfactorily such further period of training as the Secretary of State may prescribe.

Candidates may be required to appear before a Selection Committee at the India Office. They will also be required to pass a medical examination if selected for appointment.

The Regulations in respect of the appointments and Forms of Application for use by candidates can be obtained on application to the SECRETARY, PUBLIC WORKS DEPARTMENT, India Office, Whitehall, London, S.W. 1. Applications for appointment must reach the India Office not later than 15th November, 1921.

INDIA OFFICE,
22nd September, 1921. S 162

Accountant Wanted to go to

France for the purpose of investigating accounts connected with contracts for the purchase, delivery and erection of heavy machinery for steel works.

Address, CHAS. G. BIGGS, Royal Metal Exchange, Swansea. S 170

Assistant Inspector Wanted

for Continent. State experience, age, and salary required.—Address, S 204, Offices of ENGINEERING.

Manager Wanted for Small

up-to-date Works, manufacturing Machine Tools — greater London area. — Address, stating experience and salary required, S 183, Offices of ENGINEERING.

Wanted by Firm of Consult-

ing Engineers and Naval Architects in Glasgow, JUNIOR ENGINEERING ASSISTANT. Applicant must have drawing office and sea experience. State age, experience, and salary expected.—Address, "NAVAL," WILLIAM PORTEOUS & Co., Advertising Agents, Glasgow. S 112

Assistant Engineer Wanted

for the Far East, age 28 to 30 years. Knowledge of Diesel Engines. Salary £32 10s. per month and free passage. Write giving brief record of education and career to BOX 8307, LEE & NIGHTINGALE, Advert. Offices, Liverpool. S 138

Engineer Wanted for Important Post

in healthy part of the East.

Applicants should be thoroughly qualified Mechanical Engineers with Civil Engineering experience. Training should embrace all-round experience including Drawing Office work.

Only men of undoubted initiative with the ability to control staff and labour, and of good address and good social standing need apply.

Applicants must give full details of their scholastic, shop, and University training, stating degrees, if any.

Replies should be addressed S 200, Offices of ENGINEERING.

Senior Draughtsman and

ESTIMATOR REQUIRED. Full knowledge of elevating, screening and Contractors' plant. Must be capable of producing matured designs. —Address, stating age, full experience and salary required.—S 156, Offices of ENGINEERING.

Draughtsman Required, used

to Concrete Mixing Machinery and Plant.—State full experience and salary required.—Address, S 197, Offices of ENGINEERING.

10-IN. AUTOMATIC TURRET LATHE.

THE advance which machine-tool design has made in recent years, and is still making, is well illustrated by the remarkable automatic lathe which we are able to illustrate in considerable detail this week. This machine, which is known by the makers as the Gisholt 20-in. automatic turret lathe, is constructed by Messrs. The Gisholt Machine Company, of Madison, Wisconsin, U.S.A., their agents in this country being Messrs. Burton, Griffiths and Co., Limited, of 64–70, Vauxhall bridge-road, London, S.W. 1. The lathe, as will at once be gathered from the general view given in Fig. 1, subjoined, is of the chucking type. The duty of the operator is confined to placing the

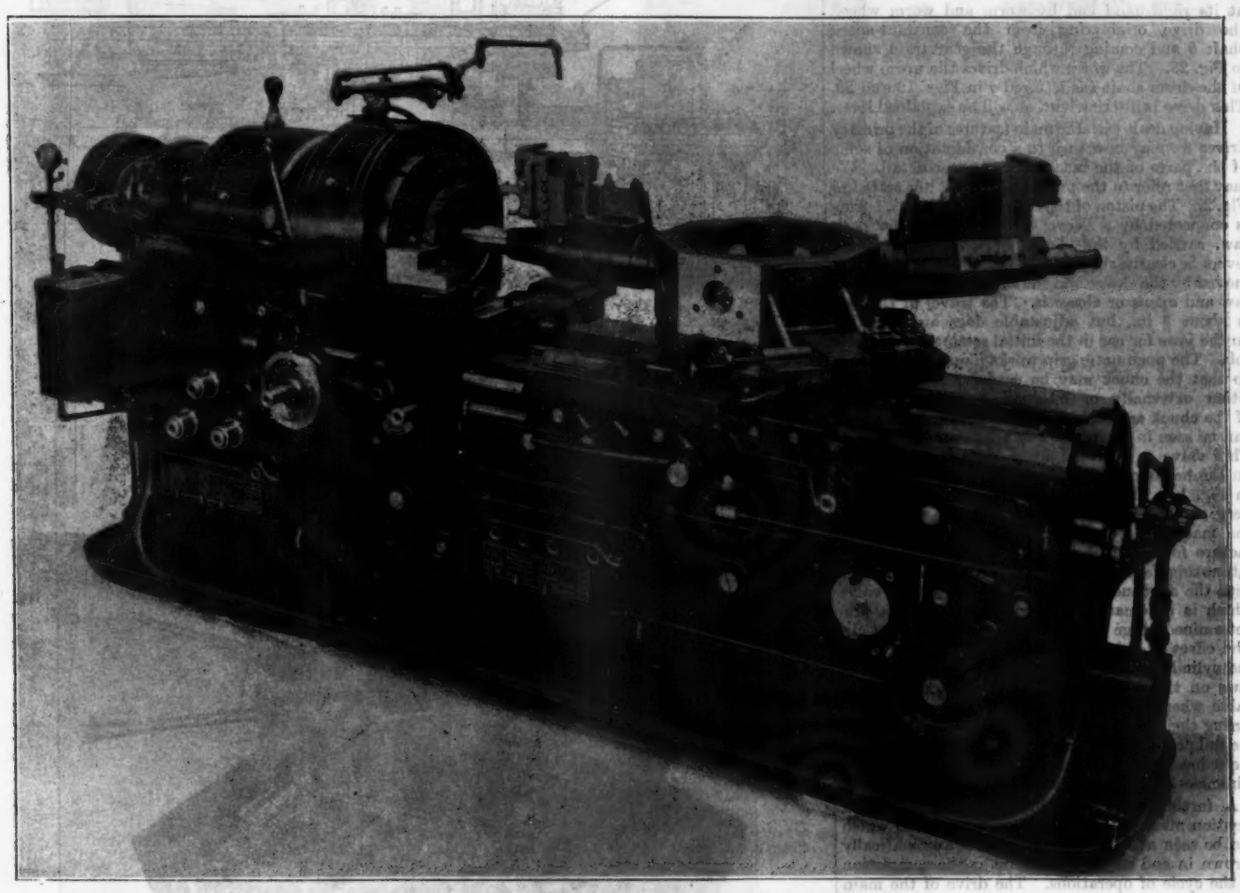


FIG. 1. 10-IN. CHUCKING TYPE AUTOMATIC TURRET LATHE.

successive pieces which have to be machined in position in the chuck and removing them when they have been completed. The whole of the machinery operations are automatic. The lathe is of 10-in. centres, or 20-in. swing, and will consequently deal with fairly large work; as it is also a powerful and stiff tool it is capable of handling a big range of jobs and ensuring some remarkable outputs. It is to be feared that the potentialities of such a machine as this are not as generally recognised in this country as they should be. It is by no means only in motor-car manufacture that an automatic such as this will quickly justify its cost, and the capabilities of the machine will be found worthy of careful consideration by a large range of manufacturing engineers.

As already mentioned, the normal swing of the lathe is 20 in. The swing over the cross-slide is 16 in., and the diameter of the spindle hole is 4¼ in. The maximum distance between the chuck and the turret is 45 in., and the maximum length of work which can be handled 14 in. The machine has an overall length of 11 ft. 10⅝ in. and a weight of 10,100 lb. It may be driven either by an attached electric motor or by belt. With the belt drive a 14-in. pulley is used on the headstock and is driven at 400 r.p.m. The lathe incorporates a number of novel and important features, one of the chief of which lies in the fact that no cams are used for obtaining turret or cross-slide motions. All drives of this kind are through lead screws, the motions of which are controlled by drums carrying small adjustable blocks, or tappets, which operate the speeds and feeds. The lathe is also fitted with a pneumatic chuck which, owing to the rapidity of its operation greatly adds to the possible output especially of pieces for which the machinery time is short. This chuck, together with some details of the main drive, is illustrated in Figs. 2 and 3, on page 464. We will refer more fully to these figures a little later. In this preliminary survey the only other feature to which we would direct attention is that the turret is octagonal, as is well shown in the general view given in Fig. 4, on page 464. An important point in connection with this feature of the machine is that when it is in operation the turret automatically revolves past any number of faces, as may be required in any position on the bed, and does not have to return to the outer end position for each step round, as is not unusual in automatic chucking lathes. This feature naturally assists output.

As the machine incorporates a large amount of detail it will probably be best in describing the various actions if, in the first instance, an indication of the principal drives is given in general terms and the more interesting detail features of these drives dealt with later. The main drive we have already indicated in connection with Fig. 2, which shows the main pulley *a* inside its guard. This pulley drives through a friction clutch on to the constant-speed shaft *b*. This clutch is controlled by a stop lever, which can be seen in Fig. 1, and is also shown in the elevation of the machine given in Fig. 5, on Plate XXVI. The throwing out of this clutch, of course, stops the whole machine at any time. The headstock spindle is driven by gears which are clearly shown in Fig. 2, the final drive being from the pinion *c* direct on to a gear rim mounted on the chuck. The constant-speed shaft *b* is carried the full length of the machine and runs all the time the lathe is in operation. Its continuation through the bed is shown in Fig. 18, on Plate XXVI. From its right-hand end this shaft drives the rotating shaft *d*, which serves to impart the rotary drive to the turret. This shaft *d* also runs continuously. Its position in reference to the turret slide is indicated in the cross-section given in Fig. 26.

The constant-speed shaft *b* also drives the feed shaft by chain from the chain wheel which can be seen at about the centre of Fig. 18. The feed shaft itself is illustrated in Fig. 11. The shaft is indicated by the letter *e*. This shaft runs at a constant speed, but drives the next link in the chain, the intermediate shaft, at different speeds depending on the position of the feed clutches. The intermediate shaft, which is lettered *f*, is illustrated in Figs. 7 and 8. These two figures show the same shaft, Fig. 8 being the right-hand continuation of Fig. 7. As will be seen from these figures this intermediate shaft *f* carries a series of worm wheels which are driven by the worms carried on the cross-shafts shown in Fig. 11. The worms, as will be seen, are driven through the various feeds and, depending on which clutch of Figs. 7 and 8 is engaged the intermediate shaft runs at various speeds.

The transverse of the turret and the motions of the cross-slide are obtained from the intermediate shaft. The turret drive is taken from the spur wheel *g* mounted at the end of the intermediate shaft and shown in Fig. 8. This wheel gears with a spur wheel on the end of the turret lead screw, as is clearly shown in Fig. 17. The gear wheel *g* is indicated by dotted lines in this figure. The drive

from the cross-slide is obtained from the clutch controlled spur wheels to be seen to the left-hand side of Fig. 7. These drive a double pinion *h*, which, in turn, drives the train controlling the cross-slide. The double pinion *h* is carried by the constant speed shaft *b*, but is not secured to it and runs loose on a bush, as can be seen in Fig. 2. The only remaining main drive to which we need refer before dealing with some of the arrangements in greater detail is that of the drum shaft, which is carried the full length of the base of the machine near the bottom, and is indicated by the letter *i* in Fig. 12. This shaft carries the drums to which are fitted the tappets controlling the levers which operate the clutches carried by the intermediate shaft *f*. These clutches, as before explained, control the feed of the turret and cross-slide. The drum shaft *i* is driven at its right-hand end by worm and worm wheel, the drive originating from the constant-speed shaft *b* and coming through the gear train shown in Fig. 28. The worm which drives the worm wheel of the drum shaft *i* is lettered *q* in Figs. 12 and 28. This drive is intermittent, as will be explained later.

Having dealt with the main features of the primary drives we may now turn to a consideration of some of the parts of the machine in greater detail. We may first refer to the pneumatic chuck illustrated in Fig. 2. The piston of the chuck is shown at *j*. This is connected by a sleeve with levers, one for each jaw, carried by the chuck proper. One of these levers is clearly shown in Fig. 2. The long arm is moved by the sleeve and the short acts on the chuck jaw and opens or closes it. The travel of the jaw is about $\frac{3}{8}$ in., but adjustable dogs are provided on the jaws for use in the initial setting up of a new job. The pneumatic grip works in either direction, so that the chuck may be used for holding a job either externally or internally. The movements of the chuck are controlled by a piston valve which can be seen in the upper left-hand corner of Fig. 2. This valve is operated by a hand-lever mounted on the headstock near to the work, as can be seen in Fig. 1. The whole arrangement lends itself to very rapid removal and insertion of work when the machine is engaged on the repetition manufacture for which it is intended. A further very interesting feature is incorporated in connection with the air chuck. This consists of a relief valve which is automatically cut into circuit at a predetermined stage in the machining of an article. The effect of this is to reduce the air pressure in the cylinder and consequently the pressure of the jaws on the work. The device is particularly of value when light articles are being turned which, during their finishing stages might be deformed by the full pressure of the chuck. For the finishing cut the reduced pressure gives all the grip necessary and minimises risk of deformation.

A further feature of the headstock of which mention must be made is the friction clutch which can be seen at *k*, in Fig. 2. This is automatically thrown in and stops the spindle at the completion of the cycle of operations. The drive of the main spindle, as illustrated in Fig. 2, we have already referred to, but we may say here that the standard spindle speeds are 13 r.p.m., 21 r.p.m., 32 r.p.m. and 53 r.p.m. These are obtained by back-gear ratios of 7, 12, 18 and 32 to 1. An end view showing the construction of one of the friction clutches by means of which the different gear wheels are put into circuit is given in Fig. 3. The clutches, as will be seen from Fig. 2, are themselves operated from sliding grooved-sleeves which are moved to the right or left as may be required, by rocking levers operated by the spindle speed drum. This drum is the one shown to the left in Fig. 12. The long lever is that which operates the main spindle friction brake and those on either side of it are the levers controlling the spindle speed gear wheels. The short lever at the right-hand end of the drum operates in connection with the cross-slide and we will refer to it again later. The method of operation of these levers will be fairly obvious and requires little comment. Small trip blocks are secured by set screws on to the drum, in positions selected to suit the job being worked on. The drum is driven as we have already explained, and as the stop blocks come round they engage rollers on the lever ends and force the levers over.

We may next deal in rather more detail than we have yet done with the turret drive. As already explained, the turret traverse is obtained from the gear wheel *g* carried on the end of the intermediate shaft *f*, as shown in Figs. 8 and 17. The variation in speed of traverse is controlled by the right-hand drum of Fig. 12. Of the four levers working on this drum, as shown in this figure, the first and third counting from the left-hand end, that is, those lettered *l* and *n*, are the ones controlling the turret traverse speeds. These operate clutches in the same manner as explained in connection with the headstock drum. The levers *l* and *n* are shown in Fig 8, and it will be seen that they are connected to links to other levers which actually carry the clutch operating forks. The arrangement will be quite clear from Fig. 8, and it will be obvious that the only reason for introducing these links has connection with the general layout of the machine and the desire to bring all turret controls to a

Fig. 2.

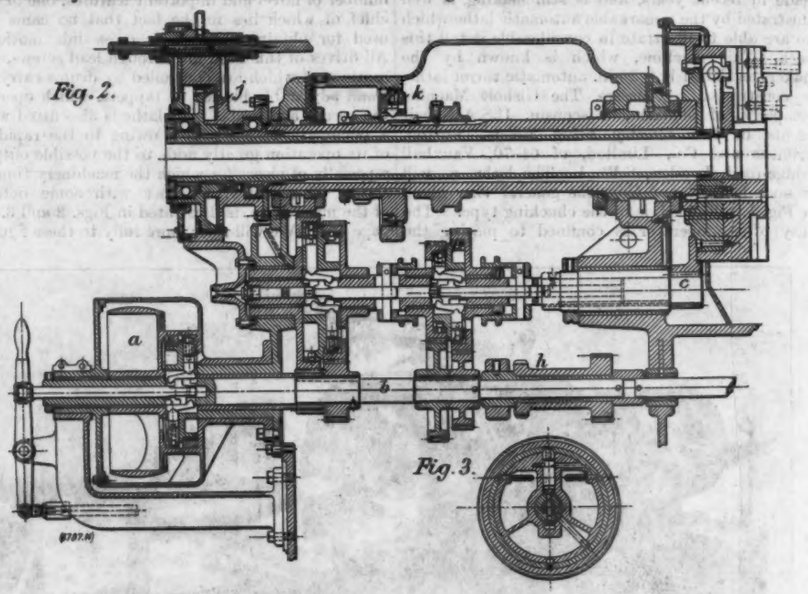


Fig. 3.

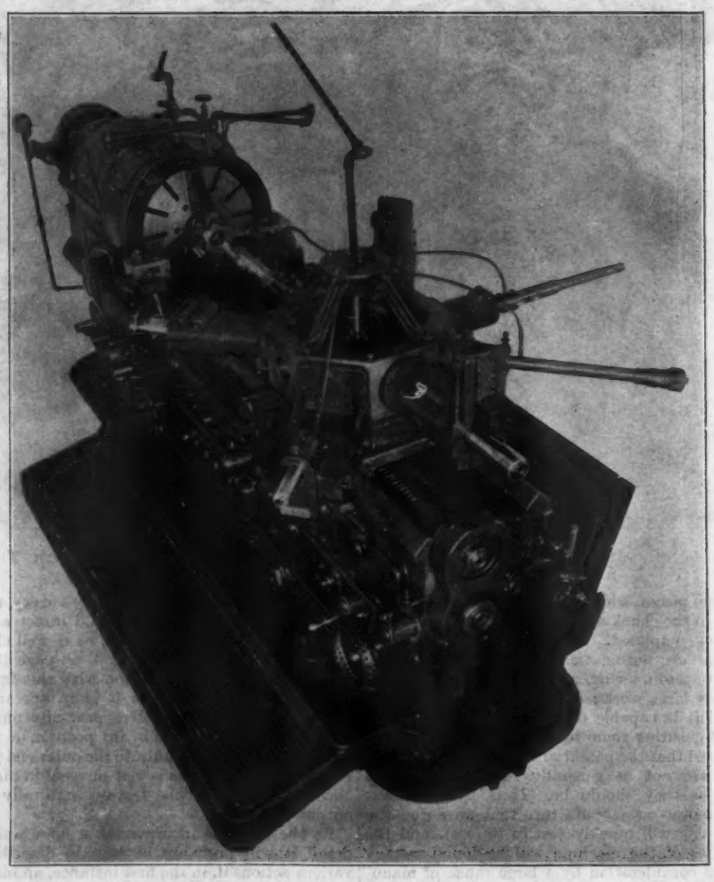


FIG. 4.

common drum. The clutches operated by lever *l* lie, as will be seen, on the part of the intermediate shaft which is shown in Fig. 7. The operation of these clutches throw the intermediate shaft drive on to one or other of the worm wheels which are shown in Figs. 7, 8 and 11. These wheels are carried by the cross-shafts shown in Fig. 11 and already referred to, and as will be seen from this figure the drive from the feed shaft *e* on to these cross shafts is through gear boxes on the back of the machine. These gear-boxes can be seen in Fig. 6.

In the operation of the machine four turret traverse speeds are available, in connection with the mechanism we are describing, through the four worm wheels shown in Fig. 11. In setting up for a job, however, any of the four speeds may be varied over a range of 4 to 1 by altering the wheels in the gear boxes. These are immediately accessible from the back of the machine, as will be clear from Fig. 6. Of the four feeds, that usually used for roughing ranges from 12 to 48 cuts per inch, that for finishing from 6 to 24 cuts per inch, and that for reaming from 3 to 12 cuts per inch. The fourth feed is a fine one and ranges from 0·003 in. to 0·012 in. feed per revolution of the spindle. In addition to these various turret feeds, rapid traverse both forward and reverse is provided. This is controlled by lever *m* of Figs. 8 and 12. As will be seen from Fig. 8 this lever throws the drive of the intermediate shaft on to one or other of two spin wheels which revolve in opposite directions. These are driven through gear trains from the spin wheel *p* mounted on the constant-speed shaft *b* and shown in Fig. 18. The lever *m* is thrown in or out of gear in either direction by means of tappets on the feed drum exactly as already explained in connection with the feed levers.

In passing to a description of the trip gear and feed altering arrangements, we should make it clear that the drum shaft *i* of Fig. 12 is normally at rest during machining operations and only rotates during feed or speed changes. We have already referred to the intermittent drive of this shaft through the worm *q* which is shown in Figs. 12 and 28. The initial point from which feed and speed changes originate is the trip table which can be seen in front of the turret in Fig. 1, and a little ahead of the turret in Fig. 5. This table is made with a series of tee slots in which trip blocks can be clamped. These blocks can be so placed that one or other of them comes into engagement with a trip on the turret, and by suitably setting the block the change motion may be set in operation at any part of the turret travel to suit any job being machined.

The trip table, as is best shown in Fig. 5, is carried on a pair of swinging links, and when a trip takes place the table is depressed and the links swing downwards. This slightly rotates the spindle shown at *t* in Fig. 5, through the two levers and link mechanism. This spindle *t* is also shown in Fig. 33, and a study of that figure will make it clear that the movement of the trip table causes the arm carried by the spindle *t* to push round the bell crank lever *u* and release the catch holding the arm *v*. This arm is shown in the detail given in Fig. 32, and from that figure it will be seen that the spindle carrying *v* also carries a fork which operates a clutch *w* containing an internal spring controlled pawl. This clutch *w* is also shown in Fig. 28, which is a cross-section through the bed of the lathe in the neigh-

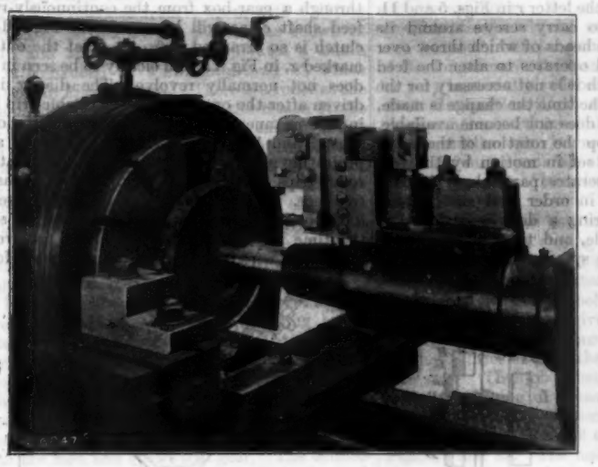


FIG. 36.

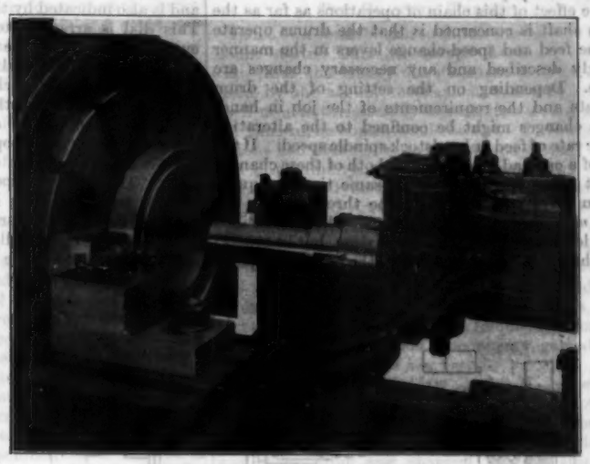


FIG. 37.

Fig. 38

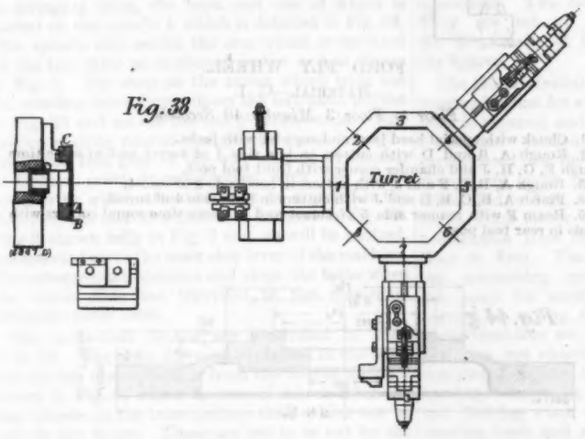
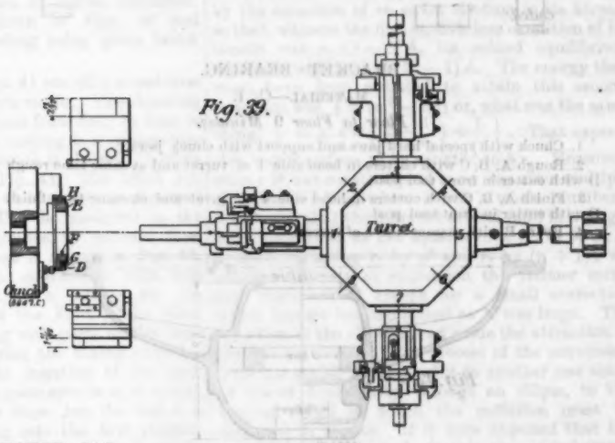


Fig. 39.



PART COMMUTATOR CAP.

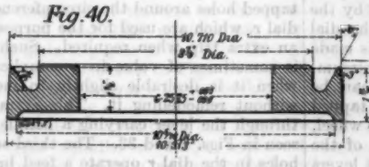
MATERIAL—CAST STEEL.

Floor to Floor (Two Operations) 35 *Minutes.*

First Setting.

1. Chuck with special hard jaws.
2. Face A and B with cutters on angle plate side 1 of turret.
3. Rough turn C with head side 4 of turret.
4. Finish turn C and round corner with cutter on head side 7 of turret and finish face B with cutter in front tool holder.

Fig. 40.



Second Setting.

1. Chuck with special jaws.
2. Rough bore F, H and G with cutters in bar and head side 1 of turret, and at same time rough face D and E with cutters in front tool holder.
3. Finish face E with cutter in rear tool holder.
4. Finish bore F and round corner with cutter in bar and head side 3 of turret.
5. Ream F with reamer in side 5 of turret.
6. Finish H and G and round corner with cutters in head side 7 of turret.

bourhood of the index dial. This clutch w, as will be seen from this figure, transmits the drive from the constant-speed shaft b to the worm q which drives the drum shaft and the index dial. It will be evident from a consideration of this train of motions which we have described that the motion of the turret trip table sets the drum shaft and the index dial in operation.

The effect of this chain of operations as far as the drum shaft is concerned is that the drums operate on the feed and speed-change levers in the manner already described and any necessary changes are made. Depending on the setting of the drum tappets and the requirements of the job in hand, these changes might be confined to the alteration in the rate of feed or headstock spindle speed. If the end of a cut had been reached, both of these changes might take place, and at the same time the quick return turret traverse might be thrown in by the lever m. The train of motions as we have described them leave the drum shaft in rotation, but in general this shaft will come to rest after the necessary speed, or feed, changes have been made by the drum levers. To stop the drum shaft it is necessary to disconnect the clutch w. We will deal in a moment with the gear by which this is carried out, but before describing it may refer to the gear by which the backward travel of the turret slide is controlled. This is done by the action of the trip lever d^1, which can be seen in Figs. 5 and 8. This lever intercepts an adjustable block on the turret slide, so that as the turret travels back from the work, to allow clearance for the bar to swing round for the next machining operation, the block comes in contact with the trip lever d' and swings it on its pivot. The lower arm of this trip lever is connected by a link to an arm c^1 mounted on, but not connected to, the spindle which carries the arm v of Fig. 33. The arm c^1 is well shown in Figs. 8 and 29.

The upper end of the arm c^1 controls a clutch b' which is shown in Fig. 8. This clutch is interposed between the intermediate shaft f and the gear wheel g which drives the turret lead screw, as already described. The effect of the action of the lever d^1 is consequently to disconnect this clutch so that the drive of the turret lead screw is stopped and the turret comes to rest. A band brake, details of which are given in Figs. 9 and 10, is incorporated in connection with this clutch. This brake acts on the driven part of the clutch and helps to absorb the momentum of the heavy turret as it comes to rest. The resetting of the clutch b' for taking up the drive for the next machining operation is accomplished from the lever o, which is controlled by the right-hand drum of Fig. 12. The clutch during setting up, or when necessary, may also be operated from a square socket into which a handle may be inserted. This socket can be seen in Fig. 1, and is shown in cross-section in Fig. 29.

The remaining important feature of the trip gear is the index dial which can be seen on the front of the machine at the right-hand end, in Fig. 1, and is also indicated by the letter r in Figs. 5 and 11. This dial is arranged to carry screws around its outer circumference, the heads of which throw over the trip gear. The dial operates to alter the feed or speed in cases in which it is not necessary for the turret to travel back at the time the change is made, so that the trip lever d^1 does not become available. The dial also acts to stop the rotation of the drum shaft when it has been set in motion by the trip table. The dial also operates particularly in connection with fine feeds in order that such a feed may be maintained during a definite number of revolutions of the spindle, and to give an adjustment whereby the lathe spindle can be allowed to make a few additional revolutions before the saddle moves after the feed is disengaged in order that the tool marks may be removed from the job. The dial also operates a feed brake which stops the feed instantly when required in connection with boring or machining to a shoulder.

The dial rotates at the same time as the drum shaft and is driven from it by a speed gear, as is quite clearly shown in Figs. 11 and 12. The spiral wheel on the index dial spindle is indicated by the letter s in these figures. The details of the dial r are best seen from Figs. 1 and 11. It is made with a double row of tapped holes round its circumference into which cheese-headed screws can be screwed. There is also a series of similar tapped holes round the edge of the inner face of the wheel, as indicated in Fig. 11. In the operation of the disc the heads of these screws act on tappet levers and control the throwing-in or tripping-out of the various feeds, screws being inserted, or removed, as may be necessary to suit the job being machined. The dial controls the feeds through an extension of the same trip mechanism which operates in connection with the table trip as already described. The mechanism is shown in Fig. 33, the timing trip operating through the double lever y. This lever is shown in side view in Fig. 31, and it will be seen from this figure that one arm of the lever carries a roller and the other forms a pawl. The roller operates in connection with the cheese-headed screws carried round the circumference of the disc r. These screws are normally all in place, and to make the timing trip operate it is necessary to remove a screw. When this has been done and the blank space where the screw has been removed comes below the roller carried by the arm y, the arm moves inward. This causes the pawl arm of the double lever y to release the spring catch of the clutch x, which can be seen in Fig. 33 and in Fig. 11.

This clutch x is driven by bevel gearing and through a gear-box from the continuously-running feed shaft e, as will be seen from Fig. 11. The clutch is so arranged, however, that the outer disc marked x, in Fig. 11, and clearly to be seen in Fig. 1, does not normally revolve. The disc x is only driven after the operation of the double trip lever y in the manner already described. As shown in Figs. 1 and 11, the disc carries a roller on a short projecting arm, or pin, and as the disc rotates this roller trips the lever z of Fig. 33, and releases the trip gear. As the disc x is driven through a gear-box it is possible to alter its speed of rotation so that the time interval during which the tool remains in contact with the work without feeding forward may be varied. This arrangement is employed, as already explained, to enable the tool to remain against the work long enough to remove tool marks. In the operation of the gear the feed drum would be arranged to disconnect the feed while at the same time the index dial would cut the disc x into circuit, so that the required delayed return of the turret would be obtained.

As already mentioned there is a second series of tapped holes around the circumference of the index dial r, which are used for the purpose of obtaining an extra trip when required. Such an extra trip is sometimes of value in a complicated set-up or when it is desirable slightly to modify a set-up without remodelling it. This extra trip operates through the lever carrying a handle which can be seen in Figs. 1 and 33. The third series of tapped holes in the dial r operate a feed brake, as before mentioned, so that when working closely to a shoulder, or in similar situations, an instant stop may be obtained. This part of the gear works in conjunction with the clutch b' of Fig. 8, through which the drive from the intermediate shaft to the turret lead screw is taken. We have already dealt with this clutch which, it will be remembered, incorporates a brake to absorb the momentum of the heavy turret at the end of its rapid return. The clutch, however, also incorporates a second brake which is shown in Fig. 28. This is operated by the lever a', shown in this figure. The lever is moved over by coming in contact with the heads of screws carried by the index dial, and the brake

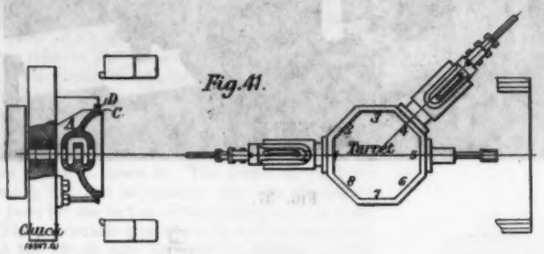


Fig. 41.

BRACKET BEARING.

MATERIAL—C. 1.

Floor to Floor 9 *Minutes.*

1. Chuck with special hard jaws and support with chuck jaws.
2. Rough A, B, C with cutters in head side 1 of turret and at same time rough D with cutter in front tool post.
3. Finish A, B, C with cutters in head side 4 of turret and at same time finish D with cutter in front tool post.
4. Ream B with reamer side 5 of turret.

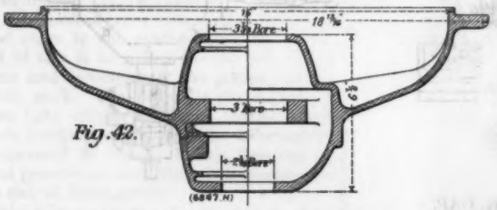


Fig. 42.

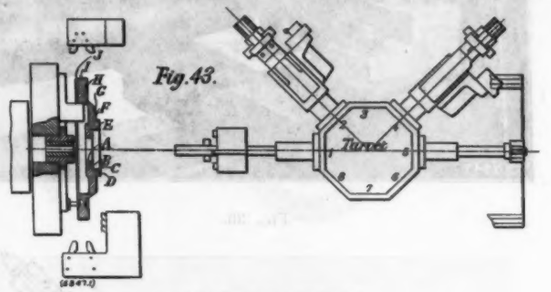


Fig. 43.

FORD FLY WHEEL.

MATERIAL—C. 1.

Floor to Floor 3 *Minutes* 40 *Seconds.*

1. Chuck with special hard jaws and support with jacks.
2. Rough A, B and D with cutters in bar side 1 of turret and at same time rough E, G, H, J and chamfer corner with front tool post.
3. Rough A, B, C, F and J with cutters in head side 2 of turret.
4. Finish A, B, C, E, G and J with cutters in head side 4 of turret.
5. Ream F with reamer side 5 of turret and at same time round corners with tools in rear tool post.

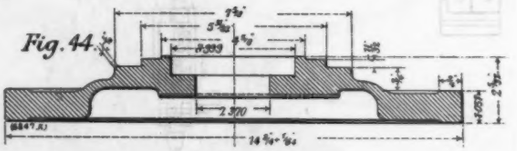


Fig. 44.

serves to stop the feed instantly when required as already described.

As we have described the turret traverse arrangements and the speed and feed control gear in considerable detail, the general lines of the machine will now be fairly well understood, and we may consequently compress our description of the remaining motions into somewhat briefer terms. The gear by which the turret is rotated is shown in Fig. 22. This operates from a worm with a sliding key which is carried by the shaft d', as shown in Figs. 18 and 22. The gear incorporates a clutch which is controlled by a swinging lever e', which can be seen in Figs. 22 to 24. There is a roller at the outer end of this lever which, on the return stroke of the turret slide, engages with a cam f' which throws the lever over and sets the turret in rotation. The position of this cam is adjustable. The rotation of the turret is stopped, when the required new position has been reached, by a stop on the turret tripping the clutch control gear. This trip gear is shown in Figs. 25 and 26. There is a stop for each face of the turret, and by setting the stops suitably the turret may be arranged to move round by any number of faces depending on what is required by the lay-out. An expanding brake, operated by cam-controlled levers, is fitted inside the turret. This comes into operation in each of the working positions of the turret and securely clamps it to the slide. Details of the arrangement are shown in Figs. 22, 24 and 27. The rotating turret, when it reaches a new working position, may be made to operate the feed and speed trip gear. The connection is made through a bar g' carried at the back of the lathe, and shown in Fig. 6. This is mounted on swinging links, the back end one of which is carried on the spindle t, which is detailed in Fig. 34. This spindle also carries the arm which is operated by the trip table as explained earlier and as shown in Fig. 5. The stop on the turret which trips out the rotating drive forces down the left-hand poppet of Fig. 25 and moves the rod g^1 downwards. This motion slightly rotates the spindle t and trips the speed and feed gear in the way already explained. A further point in connection with the turret motions to which attention may be directed is the stop rod, the end of which is to be seen in Fig. 25. This is shown fully in Fig. 6 and, as will be noticed, is connected up to the main stop lever of the machine. The arrangement operates and stops the lathe when the turret slide has travelled to the maximum allowable outer limit.

The cross-slide details are illustrated in Figs. 13 to 16. The main drive, as explained in the early part of this description, is from the double pinion h shown in Fig. 7, which in turn is driven from the gear wheels on the intermediate shaft which can be seen in this figure. These are cut in or out by the right-hand lever of the left-hand drum, as will be followed from Figs. 7 and 12. This pinion h drives a gear train which is shown in Fig. 15 and indicated by broken circles in Fig. 16. Two short cross-slide shafts which are carried in front of the machine, and can be seen in Figs. 1 and 15, are driven from this gear. The upper one operates the cross-traverse lead screw through bevel and other gearing, as is best shown in Figs. 13 and 16. The lower of the two shafts is cut as a lead screw at its outer end and serves for the longitudinal traverse of the cross-slide saddle. The cross-slide motions are connected with the main trip gear of the lathe through a trip lever h', which as shown in Figs. 14 and 15, is connected through to a lever i' on the back of the lathe. This is coupled by a link to the longer of the two levers shown at the right-hand end of spindle in Fig. 34. This spindle, as before explained, operates the trip gear. Motion is given to the lever h' by stops inserted in a disc carried on the front of the cross-slide gear, as and clearly to be seen in Fig. 1. Stops are secured to the rim of this disc to operate the lever h' as may be required by the work in hand. Details of the disc and its drive are shown in Figs. 14 and 15.

The only other detail feature of the lathe to which we have to refer is the electric controller illustrated in Figs. 19 to 21. This controller is not an essential part of the lathe, but it may profitably be fitted when the maximum possible output is desired from the machine. The controller can only be employed when the lathe is driven by an independent motor, which, however, will be the usual state of affairs. The controller is mounted at the right-hand end of the lathe, outside the frame, and is driven from the drum shaft. It is shown in position in Figs. 1 and 4, but is not indicated in Figs. 5 and 6. The controller operates in connection with a variable speed motor, and by means of it the lathe is speeded up in steps during any suitable operation. For many operations this extra speed control would be unsuitable and could not well be used, but for others, especially for some of the longer ones, the time of the operation might be very materially reduced by this power to increase the speed as the diameter of the work became less or other conditions similarly became favourable. The controller can be readily set to come into operation on any or all of the various operations making up the complete machining of any article.

This description has run to very considerable length, but before closing it we must refer to the examples of work turned out by this Gisholt automatic which are illustrated on pages 465 and 466. Three jobs with the tool lay-outs employed are shown in the figures given, and the remarkable outputs which these examples illustrate bring out the capabilities of the lathe better than any description can. The job illustrated in Figs. 36 to 40 is the machining of a cast steel commutator cap. The job involves two operations, the first of which is illustrated in Figs. 36 and 38, and the second in Figs. 37 and 39. The machined cap is detailed in Fig. 40. The total time from floor to floor for this machining is 35 minutes for the two operations. Two lathes are, of course, employed. They are set up as shown in Figs. 38 and 39, the details of the tooling being given below the figures.

The job illustrated in Figs. 41 and 42 is a cast-iron bearing bracket for an electric motor. One chucking only is required and the time from floor to floor is 9 minutes. Although the casting is a moderately complicated one the machining is simple. Tooling details are given below, Fig. 41. The third job illustrated in Figs. 43 and 44 is a cast-iron flywheel for a Ford motor car. This is machined in the remarkable time of 3 minutes 40 seconds from floor to floor. The lay-out is shown in Fig. 43. An interesting point in connection with this job may be mentioned. We believe we are correct in saying that at the Ford works when these machines are dealing with parts of this kind they are not stopped during the taking out of a completed article and the insertion of the next casting in the chuck. The main spindle is, of course, not running when this is done, but the turret is moving back and rotating into the first position again while the job is being changed. It is chiefly the rapidity of operation of the pneumatic chuck which enables this to be done. Many machine shop people will not look upon this as a desirable procedure, but it is the adoption of every method which may save seconds that enables American manufacturers to get such remarkable outputs for their tools and to produce repetition parts at costs apparently far below those which we can achieve.

A further point in connection with this Gisholt automatic which may be mentioned is that for the machining of relatively simple articles, two complete tool lay-outs may be mounted for one complete cycle of the machine. This forms a further method of facilitating high output. As the turret has eight working faces, four are available for each of the complete operations, and it will be noted from Figs. 38, 39, 41 and 43, that in none of the cases illustrated are more than four faces used. For the setting-up of the machine and for recording the tool lay-outs for standard jobs "set-up sheets" are used. These contain diagrammatic representations of the drums, trip slide, &c., and are filled in by the planning department for the various jobs to be dealt with. In conjunction with diagrams of the type shown in Fig. 38, &c., they reduce the setting-up of the lathe to a mechanical operation, maintain uniformity in machinery practice and enable any lay-out to be reproduced at any time without difficulty or re-study.

THE BRITISH ASSOCIATION.

(*Continued from page 435.*)

We now proceed with our comments on the transactions of Section A and on the discussion of the Quantum Theory.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

The Quantum Theory.

In his own contribution to the discussion Sir Oliver Lodge started from Sir Joseph Larmor's conclusion—that the energy quanta might well be separated by the atomic mechanism, and that energy itself need not necessarily be discrete—a view which Mr. Darwin, he hoped, would accept. Discontinuity in time had nothing to do with second clocks; there was discontinuity in matter, not in energy itself. If a projected electron entered a Bohr atomic system and was retained, the energy gained by the system, which must be re-radiated before return to equilibrium, was $m u^2/2$, where u was the velocity from infinity. Converted into orbital velocity $v = u/\sqrt{2}$ this became $m v^2$ and was associated with an angular momentum $m v r$; writing this as $h/2\pi$ and v as $2\pi r \nu$, where ν was the frequency belonging to the orbit in question, the energy gained and requiring emission was $h \nu$.

Now by Kepler's third law $r v^2 = N \cdot 4\pi^2 e^2/k m$, where N was Moseley's atomic number for the bombarded atom, and k the dielectric constant, so that this quantity was constant for all the rings of any given atom and changed by unit steps for atoms higher or lower in the series. But the bombarded atom had stepped down one in the series by the accretion of an extra electron in its kernel, so that, whereas the first equilibrium condition of its sheath was $r_1 v_1^2 = N A$, its second equilibrium condition was $r_2 v_2^2 = (N - 1) A$. The energy that must have been radiated to attain this second condition was $\frac{1}{2} m (v_1^2 - v_2^2)$ or, what was the same thing, $\frac{1}{2} m A \left(N \left(\frac{1}{r_1} - \frac{1}{r_2} \right) + \frac{1}{r_2} \right)$. That expression was therefore to be equated to $h \nu$. Moreover, since $r v^2$ was constant, and $m r v$ was some multiple of h (say $n h/2\pi$, where n was a whole number), it followed that the different orbital radii in a single atom proceeded as the squares of n [1, 4, 9, &c.], so that, replacing r_1 by n^2 and r_2 by $(n+1)^2$, we obtained from that expression the Balmer series and other series, except for a small correction which became less significant as N was large. The retention of the electron had made the attraction of the nucleus smaller; the process of the conversion from one stable circular orbit to another one could be traced dynamically through an ellipse, to the varying speed in which the radiation must be supposed to be due. If it were objected that the gain of an electron had, on this view, precipitated an atom a step down in the series, so that it would emit a different spectrum, Sir Oliver's answer was that the percentage of converted atoms was excessively small, and that the properties of converted material must be inaccessible to observation.

Professor J. W. Nicholson, F.R.S., continuing the discussion on mathematical lines, confined himself to spectra and the structure of molecules. We had to consider asymmetrical nuclei; the two spectra of helium might be due to the two outer electrons each describing an ellipse, the axes of the two ellipses being at right angles to one another; electrons moving in different orbits in one plane might have the same or opposite directions and might wriggle into and out of their orbits—many such conditions admitted of quantising, though they did not lead to the obvious-looking models; Bohr's hydrogen molecule was impossible.

D. H. S. Allen, of Edinburgh, who spoke next, dealt with the magnetic phenomena. The late S. B. McLaren, he said, had found that the angular momentum of a magnetic system was proportional to the number of tubes of electric induction terminating on the surface and to the number of tubes of magnetic induction linked through its aperture. In the quantum theory the angular momentum was $n h/2\pi$, where n was an integer. By identifying the two expressions and regarding the charge on the magnetons as equal to the electronic charge Dr. Allen found the number of tubes of magnetic

induction to be equal to $n(h/e)$. The ratio h/e thus defined the unit magnetic tube so that one c.g.s. magnetic tube (one Maxwell) contained $2{\cdot}43 \times 10^8$ "quantum tubes." Such an electrodynamic interpretation of h had been given by A. L. Bernoulli on the assumption that an electron was moving in an orbit in a uniform molecular magnetic field. A year ago Dr. Allen showed in the Royal Society of Edinburgh that the $n(h/e)$ relation would hold without this restriction when any number of point charges was revolving round an axis at a common angular velocity, for the number of magnetic tubes passing through stationary circular orbits. When the electron orbit was elliptic, the size and shape of the ellipse depended upon two integers, n and n_1, the sum of $(n + n_1)$ representing the number of quantum magnetic tubes passing through the elliptic orbit. These arguments, on the lines of the ring electron of A. L. Parson, would give the Faraday tube a definite existence, the unit tube of magnetic induction corresponding to one quantum. Dr. Allen's model of a spinning molecule consisted of a flywheel and two driving wheels connected by a differential gearing, both independently movable also in opposite directions; the two wheels represented a double electric circuit; when one was turned, the other moved with it, and the flywheel also moved; when the first wheel was stopped, the second gave a radiation kick.

Professor William Wilson, of King's College, London, suggested the following hypotheses as most successful for the quantum theory especially in its application to spectra: (1) Interchanges between physical systems were discontinuous in character, that is to say, each system behaved normally in a conservative way and was then said to be in one of its stationary states, from which it could pass to another stationary state abruptly with the emission or absorption of a corresponding amount of energy; (2) the motion of a system in one of its stationary states was subject to Hamiltonian dynamics with relativistic extensions, involving a dependence of the mass of the electron on its velocity. In that way, Professor Wilson said, Sommerfeld had accounted for the fine structure of the hydrogen series lines. The Stark resolution of the hydrogen lines in an electrostatic field had been explained by Epstein with the aid of the classical dynamics and the quantum principles. For transitions between stationary states involving small changes the quantum theory approached asymptotically to ordinary theory. The analogy of principle of Bohr and Kramers could only be regarded as provisional. The evidence for the existence of the stationary state was not confined to spectroscopic observations, however; it was confirmed by Franck and Hertz, Richardson and Bazzoni, and Davis and Goucher; these states had then to be reckoned with as physical facts, and when they involved revolution of electrons round enlarged centres, as in the case of atoms, we were confronted with the chief difficulty of the quantum theory, namely, that the electromagnetic theory required a continuous radiation of energy from such a system. That difficulty Professor Wilson would meet by a suitable alternative of the Maxwell-Lorentz equations.

The discussion was continued by Professor J. C. McLennan and Dr. I. Langmuir. To the former of these speakers we shall presently refer. Dr. Irving Langmuir, of New York, said that Mr. Darwin had objected to attempts to explain the quantum phenomena by theories necessitating electrons which had structures more complicated than clocks. If we were to have a mechanism at all, however, we should look for it within the electron itself, although that led at first to unpleasant complications. Bohr spoke of uniquantic and diquantic orbits of an electron which itself was not supposed to change in passing from one orbit to another. Was it not more logical to assume that quantum changes caused discontinuous changes in the structure of the electron? The facts underlying the periodic law of the elements showed that the laws governing the arrangement of the electrons were essentially simple; that inherent simplicity argued for a static arrangement of the electrons, and seemed incompatible with orbital motions of such numbers of electrons as were supposed to exist in atoms. He had therefore considered whether Bohr's theory could not be deduced from reasonable assumptions regarding the properties of electrons in a static state. Now Bohr's equations for the Balmer series could be obtained if we assumed two forces between the electron and the nucleus of charge N: Firstly the inverse square law of Coulomb, secondly the quantum force $F_q = (n\,h/2\,\pi)^2/m\,r^5$, where m was the mass of the electron, r its distance from the nucleus and n an integer. That force, it was noteworthy, did not contain N nor e, the charges on the nucleus and the electron. For a free electron, not bound in the atom, n was zero, and there was no quantum force; when the electron became modified by undergoing quantum changes (resulting in the emission of radiation) it was not able to come indefinitely near the nucleus, but it tended to reach a definite position of equilibrium. The total potential energy of the atom in each of these positions was the same as the total energy of Bohr's atom, and the radius of the electron and the frequency of its oscillation agreed with Bohr, the frequency being the period of the orbital revolution. Without making further assumptions as to the properties of the electrons, Dr. Langmuir could not account for the fine structure of the spectrum lines. But his models of the hydrogen molecule and helium atom gave the total energy more accurately than any other models, and he could satisfactorily explain the fact that only two electrons occurred in the first shell of the atoms (his duplet).

Mr. Darwin briefly replied to some of the points raised.

Radiation and Absorption by Atoms.

The paper on "Radiation and Absorption by Atoms with Modified Systems of Extra-nuclear Electrons," by Professor J. C. McLennan, F.R.S., of Toronto, was the first read before Section A, and we should have mentioned it before if it had not directly borne on the quantum theory, in the discussion of which Professor McLennan took part. The paper is an account of recent work by Professor McLennan and his students. On modern views, he pointed out, the univalent atom ion of sodium contained a nucleus, an inner ring of two nuclear electrons (the duplet of Langmuir); a further ring of eight electrons, and an outer ring of one electron; in the potassium ion we had two rings of eight electrons. Neon and argon had the same structures as sodium and potassium respectively, except that the one outer electron was missing. Now argon had a blue and a red spectrum, and by sending powerful electrodeless discharges through potassium vapours they had obtained the expected spectra of the argon type. The spectrum of mercury vapour they had extended to λ 12,000 A.U. with the aid of dicyanin-stained plates and also of a thalofide cell*; radiation λ 10,140 was not absorbed by non-ionised mercury vapour, but was absorbed when the vapour was ionised. This was in accordance with Bohr's theory that an extra-nuclear electronic configuration of mercury atoms should be impressed with a modification corresponding to the absorption of radiations of λ 1,845, before they could absorb λ 10,140. Similarly they had found indications that mercury vapour could emit radiations of λ 5,461 provided they had been modified by the successive absorption of radiations of λ 2,536·72 and λ 4,389. Working with thallium vapour [with the aid of the interferometer and prisms presently to be described] they observed that the dispersion was all anomalous at λ 5,350, indicating absorptions of this radiation by non-ionised atoms of thallium. But the extra-nuclear electronic configurations of thallium should undergo modification—not necessarily corresponding to ionisation—before they were in a condition to absorb λ 5,350, and since absorption was actually observed, the experiments suggested that the required configuration had, in this case, been brought about simply by vapourising the thallium. Use was also made in these experiments with different vapours of concentric tubes from which concentric U tubes branched off.

Professor McLennan's contribution to the discussion of the quantum theory concerned the Balmer series of hydrogen. According to Sommerfeld, the lines $H\alpha$, $H\beta$, $H\gamma$, $H\delta$ should all be doublets, and the members of the doublets themselves should consist, $H\alpha$ of triplets, $H\beta$ of quartets, $H\gamma$ of quintets, $H\gamma$ being experimentally more uncertain. Further, the separations between the members of a doublet should first increase as we proceeded from $H\alpha$ more into the ultraviolet, and then become constant. In the case of hydrogen both the Doppler effect (owing to the small mass of the atoms) and the Stark effect (due to electric excitation) would be very strong. Paschen hence tested Sommerfeld's fine-line structure with helium, and he confirmed it. But Stark was not satisfied with the quantitative evidence. Making measurements with a Hilger photo-measuring micrometer, Professor McLennan found for the doublet-separation in $H\alpha$, $H\beta$, $H\gamma$ and $H\delta$, the frequency differences, in cm.$^{-1}$, 0·36, 0·36, 0·33 and 0·29—whilst Gehrcke and Lau found 0·29, 0·29, 0·31, 0·26—that is to say, the separation would diminish as we went further into regions of short wave-lengths, and the Balmer series should, from the slope of the curve, come to a limit at λ 3,648 A.U. If that were confirmed, Professor McLennan remarked, Sommerfeld's theory would be inadequate, and the Balmer series could not be classed as a subordinate series (as it was according to Bohr), but it would be a principal series.

Fused Silica Interferometer Tubes and Prisms.

The method by which Professor McLennan makes his interferometer tubes and prisms of quartz and also of pyrex glass, deserves special notice. It is based upon the researches on Welding Glass in Optical Contact, which Messrs. R. G. Parker and A. J. Dalladay, of Messrs. Adam Hilger, described before the Faraday Society in 1917.* To prevent distortion direct contact with the flame should be avoided, Professor McLennan pointed out, and the temperature be kept below devitrification, near 1,200 deg. C. In making an interferometer tube a quartz tube A B (Fig. 2) of very uniform bore, 1 cm. or 1·5 cm. in diameter, was selected, and two discs, C and D, were cut from an optically-flat plate of quartz and carefully ground down to the proper diameter. The discs were pushed 2 cm. or 3 cm. up the tube, and held there vertically by the aid of lamp carbons with plane ends. The oxy-hydrogen flame was then applied to the outside of the tube; when the tube began to soften it was pressed against the disc all round with the aid of the pointed end of a file, and the tube was finally rotated slowly for a time while kept in the tip of the flame. In the same way prisms were constructed, the discs H G and K E (Figs. 3 and 4) being in this case elliptical; the ends A and B were finally cut off. The metallic vapours, the refraction and dispersion of which were to be studied, entered the prism through the tube F D. There was no distortion, except close to the edges; if the discs

Fig. 2.

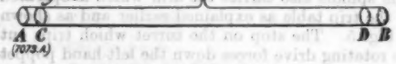


Fig. 3.

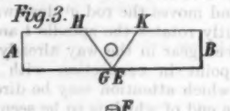
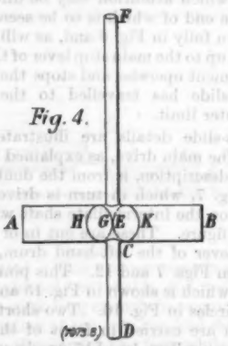


Fig. 4.



* The thalofide cell of T. W. Case resembles a selenium cell in its behaviour; a film of oxysulphide of thallium, deposited on quartz, is most sensitive to rays of 10,000 A.U.

* See Engineering, January 12, 1917, page 28.

were welded end-on, distortion would, Professor McLennan said, be more general.

The Energy of X-Radiation.

Professor C. G. Barkla, F.R.S., of Edinburgh, pointed out in his paper on the "Energy of X-Radiation" that, when α particles passed through matter, three types of emission occurred: (1) A scattered radiation, (2) fluorescent or characteristic radiation, (3) corpuscular radiation of electrons; (1) and (2) being of the nature of X-rays. All substances scattered radiations, mass for mass much to the same amount, so that the coefficient of scattering σ/s (where s was the density) had nearly the same value of about 0·2 for all substances; it changed little with the wave-length. The scattering and ordinary absorption were continuous and in accordance with the classical laws, and were not subject to a quantum effect. Nearly all the radiation energy might, and would ordinarily go into (1) or (3). The fluorescent or characteristic radiation (2), on the other hand, was an atomic phenomenon in which only a very few atoms of a system, perhaps one in many millions, would take part, and it was subject to the quantum relation. The atom had to be in a special condition to emit (2), whilst all the stable atoms would scatter radiation. During the discussion of the paper some questions were put as to the wide bearing of these suggestions.

Harmonic Analysis and Periodicity Measurements.

The simple apparatus for approximate analysis and for periodicity measurements, which Dr. W. Lawrence Balls, M.A., of Manchester, demonstrated, was devised by him in order to test an extensive series of engineering data for suspected periodicities. Finding the periodogram method which he first tried for this purpose too laborious, Dr. Balls developed—on the suggestion of Mr. G. Udny Yule—the apparatus illustrated in Figs. 5 to 10, which we reproduce by permission of Dr. Balls and of the Royal Society. Dr. Balls described this apparatus, which he calls a "harp," as simple and inexpensive and not liable to a change of zero during use. A board of triangular shape, 10 ft. long (see plan, Fig. 5, and sectional elevation, Fig. 6), is placed on a table, the wide end of the board overhanging the table. On the board are stretched in fan fashion, from the yoke y, twice nine threads of sewing cotton, each weighted at the far end where it passes over a pulley; the angle of the fan is 9 deg. The yoke y holds a strip of brass, through which twice nine holes are drilled, and is soldered to the apex of a triangular loop of steel wire, 0·01 in. thick (Fig. 7); the ends of this wire are bent round a glass rod g and screwed to the board (Fig. 8). The wire being thin, the yoke can easily move in a vertical plane, under the influence of a small force, and a concave mirror, attached to the yoke by a piece of cork, takes part in this movement; the mirror has a diameter of 2 cm. When a cardboard template of the curve to be studied is pushed under the strings, the mirror is deflected, and the deflections are observed by the aid of a ray of light falling on the mirror.

On the board are fixed a large number of pegs, arranged in diverging lines like the threads above. The pegs form a series of parallel transverse rows, 5 mm. apart (Figs. 5 and 6), and serve a double purpose: they register the position at which the template carriage may be passed under the strings, and they give sound signals. The template is attached to a frame sliding on a carriage; the carriage can be placed in any of the many portions defined by a row of pegs; in Fig. 5 a position for testing a trial period of 12·5 mm. is chosen. When the template is simply a straight edge, all the 18 threads will be equally raised, and the reflected beam, which may be sent first up to the ceiling or directly to the opposite wall on which a scale of horizontal lines is marked, will move up a certain distance; when only one string is lifted, the deflection of the mirror will be proportional to the amount of the lift; and when half the number of strings is simultaneously (or successively) raised in pushing the template under the strings, the deflection will amount to half the full height.

In pushing the curved edge of a template under the strings, however, the latter might be deflected sideways instead of being merely raised. In order to avoid this effect, the carriage is made of two parts, namely, a comb in the upper part and a slider in the lower part. The comb consists of a large number of steel needles, soldered to a strip of brass to form a comb with eight teeth per centimetre, each 8 cm. long; the teeth keep the strings in position. The comb is mounted on a hinged frame (Fig. 8) in such a way that the needles may swing clear of the threads when the carriage is to be transferred from one row of pegs to another. Fig. 8 (an end-elevation) further shows one of the V-notches fixed on the end of the wooden base of the carriage in which the template holder slides. The holder is a straight bar of metal to which is fixed a wing of tin plate h (Fig. 9) against which the template can be clipped. The sliding bar also bears a clicking spring s, which emits a click each time the spring leaves one of the 18 pegs. In shifting the carriage to another part of the board, the slide, together with the template, is turned over until it rests on two projecting arms r (Fig. 8) so as not to foul the under side of the strings while the carriage is being moved. A millimetre scale is marked on the slide. The paper for making the templates is used in strips 3 in. wide; if cut with the scissors the rough edges of the curves are rubbed with hard wax, and a hot iron is then passed over the edges. Slopes of more than 45 deg. should be avoided in preparing the curves by adopting a larger scale. When there is reason to expect a period between 5 mm. and 23 mm. the slide is first tried between the rows of pegs at 5 mm. and 5·5 mm. As the slide is being pushed in, clicks are heard, and the spot of light is seen to rise and fall, as the strings are moved; if there be a period of 5 mm. the spots of light will oscillate in synchronism with the clicks. If there be no synchronism, the next row of pegs is tried, and so on. The apparatus described admits of testing for periods between 5 mm. and 23 mm., and such determinations, Dr. Balls stated, of 50 trial periods could be made in less time than the computation of a single trial period by the periodogram method required, with an accuracy of about 3 per cent. For larger periods a different scale or a larger harp had to be adopted.

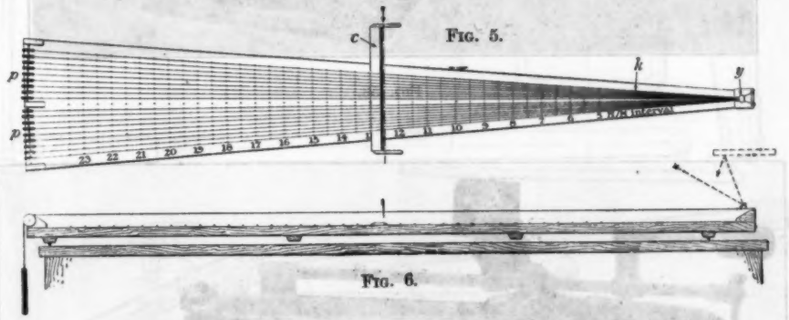


FIG. 5.

FIG. 6.

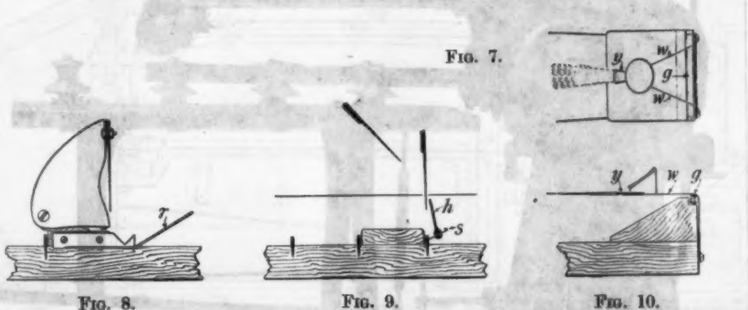


FIG. 7. FIG. 8. FIG. 9. FIG. 10.

The Recording Ultra-Micrometer.

The paper by Mr. John J. Dowling, M.A., of Dublin, on his "Recording Ultra-Micrometer," was published on page 395 of our issue of September 9. The principle is that the slightest change in the mutual distance between the two parallel plates of a condenser, produced by loading, gas pressure fluctuation or other means, is magnified by the aid of thermoionic valves and read off on a galvanometer. The extreme sensitiveness of all such valve devices, which are disturbed by the mere motion of the hand of the observer, may be overcome by providing the elaborate apparatus with a complete metallic casing and by shutting out all mechanical concussion. But the connection of the ultra-micrometer with the test piece will be difficult under any conditions. What Mr. Dowling said in his interesting demonstrations about the simplification and acceleration of chemical weighing was not convincing, and one did not see how he would actually proceed in the determination of a Young modulus on a specimen too short for ordinary testing. Such determinations have not yet been made. Similar questions were raised last year when Mr. R. Whiddington described an ultra-micrometer of that principle.

Prehensility: A Factor of Gaseous Absorption.

In his paper of the above title, Professor Henry Briggs, D.Sc., of Edinburgh, defined prehensility as the slope of an adsorbent isotherm at its origin. The paper dealt with various adsorbents, different kinds of charcoal, silica, &c., chiefly at very low temperatures (liquid air), and showed that the evacuating power of a substance could be calculated from the prehensility, and the weight of charcoal thus be determined which would be required for producing a certain reduction of gas pressure. The plumstone charcoal of Professor Briggs had given him a higher evacuating power than cocoanut charcoal. Colloidal silica was also found a good adsorbent, though four times the volume of this silica was required at — 190 deg. C. to produce the same result as the plumstone charcoal which, moreover, acted more rapidly. Very high vacua could be obtained with the aid of a succession of small charcoal bulbs, instead of one big bulb, Professor Briggs observed, but the subdivision must not be pushed too far.

The Magnetic Anomaly in the District of Kursk.

The "Magnetic Anomaly in the District of Kursk," in Russia, south of Moscow, is interesting on account of its exceptional magnitude and of the vast area it covers, and because it is ascribed to enormous hidden beds of iron ores. There are two parallel belts, about 30 miles apart, stretching in a length of 150 miles and a width of 2 miles from north-west to south-east in the Government of Kursk, over which the magnetic elements seem to

be all wrong, the declination sometimes by 180 deg.; the total intensity is very high, and there are a number of spurious magnetic poles. The anomaly has often been investigated, by Smirnoff about fifty years ago, by Pilchikoff, Moureaux and others, and finally by E. E. Leist, who having made measurements at 4,500 spots, presented a long memoir on the subject to the Scientific Institute of Moscow in 1918. The memoir was published, but without charts, and as Leist died soon afterwards, and his papers were lost or inaccessible, L. R. Krassin, on behalf of the Russian Government, charged Professors Lazareff and A. Kriloff, both members of the Petrograd Academy, with a new magnetic survey. Professor Kriboff communicated to Section A the results of this survey, which was made, partly during the civil war, with instruments such as used in the Russian Navy, and does not claim high accuracy. Disturbances in the magnetic intensity amounting to 120,000 γ ($1\gamma = 10^{-5}$ gauss) were observed, whilst the late Dr. G. W. Walker—his death was announced during the meeting by Professor H. H. Turner—in this Magnetic Re-survey of the British Isles for the Epoch, January 1, 1915 (Philosophical Transactions, 1919), as quoted by Kriloff, mentioned a maximum anomaly of 500 γ and connected it with something like 50 million tons of concealed iron ore. We might mention that the Iron Ore Committee (Dr. A. H. Cox and Professor E. Wilson) working in conjunction with Dr. Walker in this re-survey [the original survey by Sir Arthur Rücker and Sir Edward Thorpe, the president of the Edinburgh meeting, referred to 1886 and 1891] came to the conclusion that the amount of a magnetic disturbance need not be a direct measure of the iron present in the earth, because, among other reasons, the oxide Fe_3O_4 has a very much greater magnetic susceptibility than the other iron ores. But iron prospectors, of course, attach much importance to magnetic disturbances.

(*To be continued.*)

THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

(*Concluded from page* 439.)

THERE was much interesting material at the Olympia Exhibition with which we have not yet dealt, and although we cannot pretend to find space for a description of every exhibit, we propose in this final article to at least add to the number of our notices and to describe some important exhibits which the exigencies of space or other considerations have prevented us dealing with earlier. A very interesting display, to which we made brief reference last week, was made by the A.1 Manufacturing Company, of Industry Works, Sunbridge-road, Bradford. This covered a very complete collection of electric welding machines which included spot, seam and butt welders. The firm also showed two electric rivet heaters of the type which has shown signs of developing very rapidly in this country of recent years. In these machines the rivet is held vertically between two copper contacts, and tappings are provided on the transformer to give various rates of heating. The conveniences of this type of rivet heater in the rapidity with which work can be started up and the absence of burned rivets are now becoming generally realised.

From among the various electric riveters of the firm we illustrate three types on this and the opposite pages. These are all machines of the seam-welding type. This type of welding presents difficulties which are not met with in the simpler spot welding and is of a class which before the war was to a considerable extent catered for only by German and American machines. In the past there has always been a difficulty in electric resistance seam-welding when the metal being dealt with was other than a light class, and a thickness of about No. 20 S.W.G. has represented the limit which could be dealt with. The difficulty with the welding of thicker sheet arises from the relatively long time required for the heating up of the joint and the consequent slow speed of traverse which for commercial success must be kept up to a reasonable minimum. If the current passing is pushed up so high as to heat the joint rapidly enough to allow of rapid traverse, there is danger of burning the metal. This difficulty has been met by various step-by-step methods in which the current is applied intermittently and for short periods only. This procedure is practically a form of spot welding, and by overlapping the spots a perfect seam can be obtained. The process is somewhat slow, however, owing to the time lost in raising the pressure between the progressive spots, while the lack of a continuous pressure when the metal is in a semi-molten state is not desirable.

This difficulty has been overcome in the seam welders of the A.1 Manufacturing Company by a method of interrupting the primary current a number of times a second. The number of interruptions varies with the speed of travel of the article being welded between the rollers. From 15 to 35 interruptions per second is the usual range. In relation to the traverse the duration of

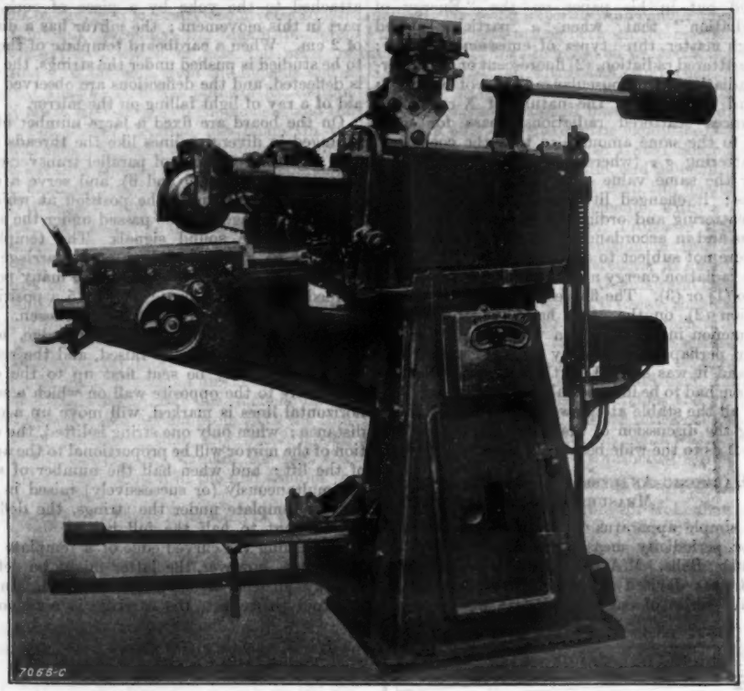


FIG. 53.

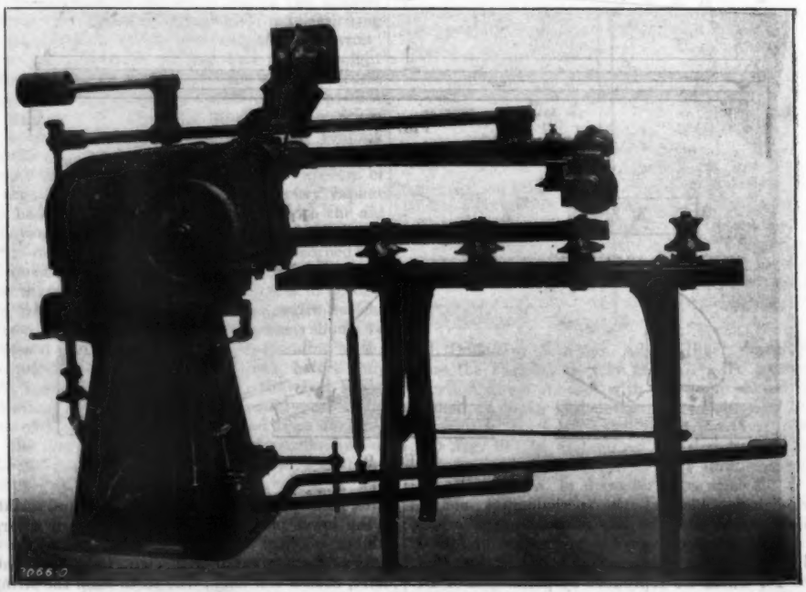


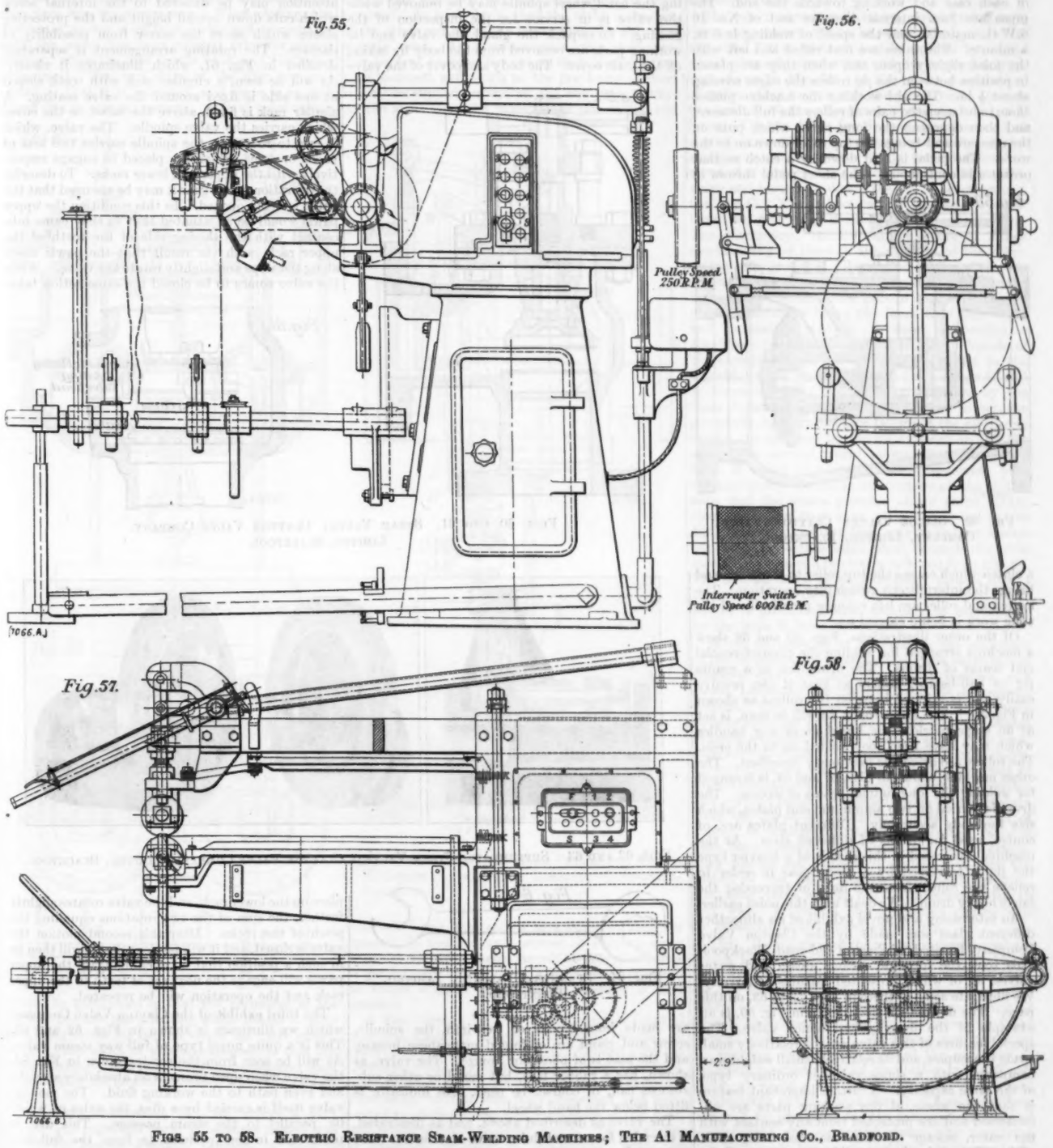
FIG. 54.

FIGS. 53 AND 54. ELECTRIC RESISTANCE SEAM-WELDING MACHINES; THE A1 MANUFACTURING COMPANY, BRADFORD.

the current is about $\frac{1}{16}$ in., with an interruption of about $\frac{1}{16}$ in., and as the length of material at any time under pressure and contact between the rollers is approximately $\frac{1}{2}$ in., four to five interruptions and contacts take place while any given portion of the work is passing under the rollers. The result is that complete overlapping of the current contacts takes place with continuous pressure, and a current sufficiently high to weld up to No. 10 S.W.G. at a rapid speed can be applied. The devices for interrupting the primary current have been patented throughout the world by the Al Company, while they, in addition, have a patent make and break switch which carries out the interruption without undue noise or arcing.

Of the seam welding machines we illustrate that shown in Fig. 53 is arranged for welding together the long strips of sheet metal used for armoured cable work. The strips as made are welded end to end to form still longer strips. As will be seen the machine is fitted with a special bracket which carries the jig and holds the strip firmly while the weld is taking place. The other illustrations show machines arranged for welding circular drums and similar articles and it is more especially this type of welding with which we wish to deal. It will be gathered from the machine illustrated in Figs. 54 to 56 that the welding rollers are power driven so that they traverse the work being dealt with. In the case of the larger machine, however, which is illustrated in Figs. 57 and 58, the material is driven instead of the rollers. The object of this difference in method is to make the lighter machines more suited for general use as illustrated in the example shown in Fig. 53. The driving of the rollers in the smaller machines is quite satisfactory since the light work moves easily. The machines dealing with heavier work are in general required only for special work, such as the manufacture of drums, and as these are heavy they do not travel easily, so that the work itself is driven to eliminate possibility of slip or lack of traverse.

The machine as actually shown in Fig. 54 is arranged for welding stack pipes for house purposes and irrigation work. This type of work has become



FIGS. 55 TO 58. ELECTRIC RESISTANCE SEAM-WELDING MACHINES; THE Al MANUFACTURING CO., BRADFORD.

of much importance in connection with the extensive house building now being carried on. The pipes are made from black mild steel sheet galvanised after welding. The machine is arranged for seam welding pipes, 6 ft. long, welding being carried out in two lengths of 3 ft., starting from the centre of the pipe in each case and working towards the end. The pipes are 3-in. internal diameter and of No. 16 S.W.G. material, and the speed of welding is 6 ft. a minute. The tubes are first rolled and left with the joint slightly open, and when they are placed in position between the jig rollers the edges overlap about ¼ in. The girl working the machine pushes them in between the pairs of rollers the full distance, and then depresses the long pedal which puts on the pressure and brings the top roller down on to the work. The pedal is held down by a catch so that pressure is continuous. The short pedal throws in

Fig. 59.

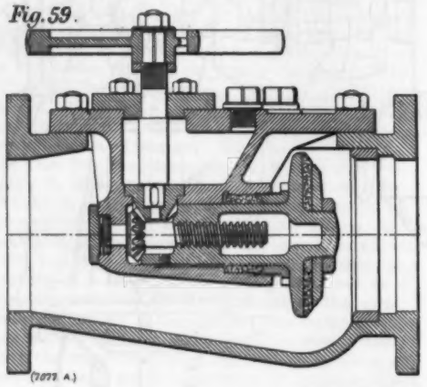


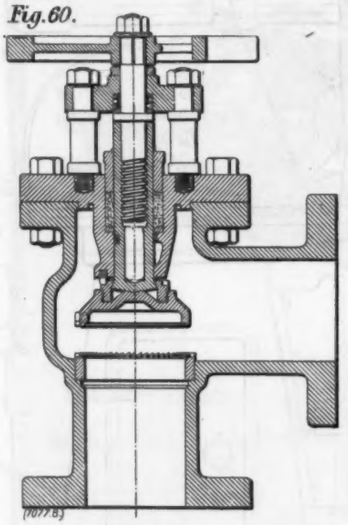
FIG. 59. SLUICE VALVE: CLAYTON VALVE COMPANY, LIMITED, BLACKPOOL.

a clutch which causes the top roller to be driven and brings the intermittent switch into operation. The switch and roller are left running practically all the time work is being carried on.

Of the other illustrations, Figs. 55 and 56 show a machine arranged for welding the circumferential end seams of drums. The drum lies in a cradle jig on ball-bearing rollers so that it can revolve easily and is gripped between the rollers as shown in Fig. 55. The lower roller, as will be seen, is set at an angle to clear the bunghole or any handles which may have been spot welded on to the ends. The rollers are driven as previously described. The other machine, shown in Figs. 57 and 58, is arranged for welding the longitudinal seams of drums. The drum is carried on two aluminium end plates, which size the body accurately. Different plates are, of course, used for drums of different sizes. As the machine illustrated in this case is of a heavier type the jig is traversed by a worm gear in order to relieve the rollers from the duty of traversing the fairly heavy drum. We dealt with this point earlier.

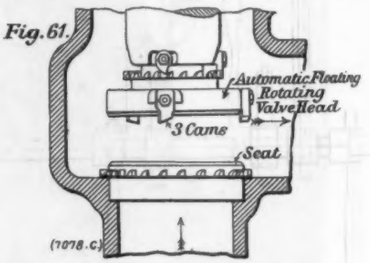
An interesting and novel exhibit of an altogether different class was made by the Clayton Valve Company, Limited, of Preston Old-road, Blackpool. This took the form of various steam and water valves, all of which presented features of novelty. We illustrate some of these in Figs. 59 to 63, on this page. The first valve, that shown in Fig. 59, is an example of the firms patent sluice valve. The special features of this valve are the relatively small space it occupies, and its relatively small weight was, compared with a sluice valve of ordinary type, of the same capacity. A further important feature is that the whole of the working parts are oil-immersed and are protected from any contact with the water, sewage or other material being dealt with. The main features of the valve will be easily followed from the illustration. As will be seen, the valves pindle lies at right angles to the operating spindle carrying the hand wheel, and the two are connected by bevel gearing. The chamber in which this gearing works and also the chamber containing the screwed end of the valve spindle act as oil reservoirs so that the parts are continually oil immersed. A screwed gland with packing isolates this oil chamber from the fluid passing through the valve body. The gland is formed with teeth on its rim, and may be tightened up when the valve is closed by means of a bar inserted through a special gland plug-hole in the main cover. The thrust of the valve is taken by a thrust collar on the end of the valve spindle, and the bridge supporting the hand wheel spindle may be removed while the valve is in service for the inspection of the gearing. To re-pack the gland, the valve and its working parts are removed from the body by taking off the main cover. The body and cover of the valve

Fig. 60.

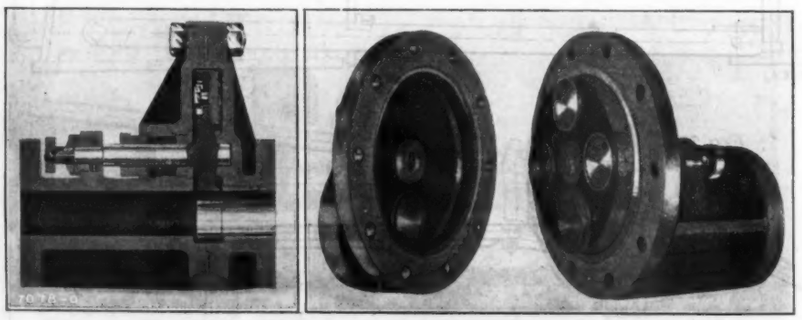


on a new bearing. This assists in maintaining tightness. This rotating arrangement is more clearly shown in connection with the valve illustrated in Fig. 60. This valve is generally of more conventional pattern than the one illustrated in Fig. 59, with which we have been dealing, but attention may be directed to the internal screw which cuts down overall height and the protecting sleeve which saves the screw from possibility of damage. The rotating arrangement is separately detailed in Fig. 61, which illustrates it clearly. As will be seen, a circular rack with teeth sloped at one side is fixed around the valve seating. A similar rack is fixed, above the valve, to the cover which carries the valve spindle. The valve, which is free to rotate on the spindle carries two sets of pawls or cams, which are placed to engage respectively with the upper and lower racks. To describe the operation of the gear it may be assumed that the valve is being opened. In this condition the upper pawls would be so situated that as they came into contact with the sloping side of the teeth of the upper rack, with the result that the pawls move along the slope and slightly rotate the valve. When the valve comes to be closed the same action takes

Fig. 61.



FIGS. 60 AND 61. STEAM VALVE; CLAYTON VALVE COMPANY, LIMITED, BLACKPOOL.



FIGS. 62 AND 63. SUPERHEATED-STEAM VALVE; CLAYTON VALVE COMPANY, LIMITED, BLACKPOOL.

Fig. 64.

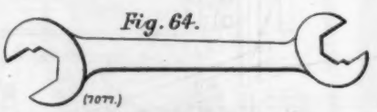


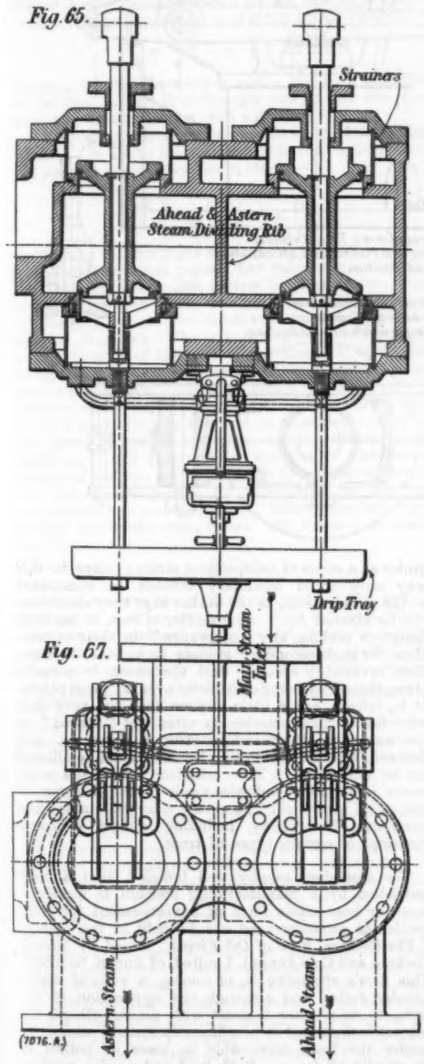
FIG. 64. SPANNER; FASTNUT, LIMITED, BRENTFORD.

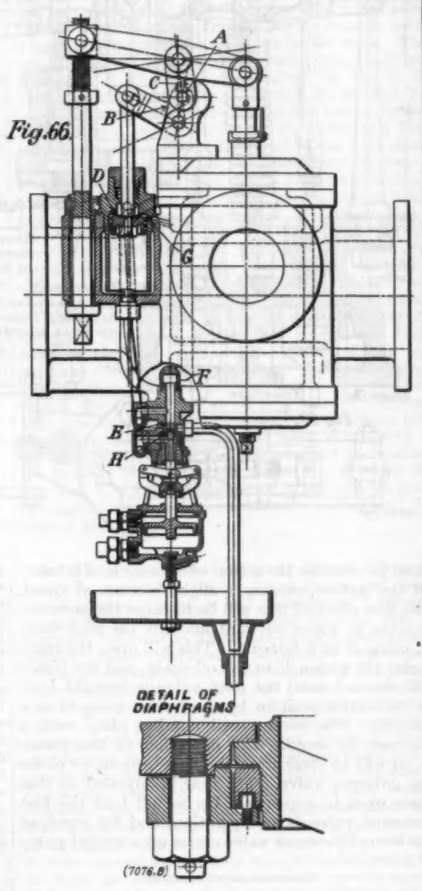
are made from bronze or cast-iron, the spindle, screw and gland are of forged manganese bronze, and the seat is of phosphor bronze. The valve, as shown, has a rubber face, but metal or other substances can, of course, be used. An indicator is fitted below the hand wheel.

The valve as described above, and as illustrated, is intended for normal sluice valve service, but what is generally the same type of valve is also built for boiler-feed service and for high-pressure superheated steam. These modifications do not alter the general lines of the valve, but differences are of course introduced in the materials of construction, while a metal-faced floating valve is used. For superheated steam work an automatic rotating arrangement is fitted in connection with the valve. This causes the valve to slightly rotate each time it is opened so that it always comes down on its seat place on the lower rack, and the valve rotates slightly further, the sum of the two rotations equalling the pitch of the racks. After this second motion the valve is closed, and it will be clear that it will then be in such a position that on opening again the upper pawls will engage the next set of teeth in the upper rack and the operation will be repeated.

The third exhibit of the Clayton Valve Company which we illustrate is shown in Figs. 62 and 63. This is a quite novel type of full-way steam valve. As will be seen from the section given in Fig. 62, the valve when open presents an absolutely straight and even path to the working fluid. The moving valve itself is carried by a disc, the axles of which lie parallel to the steam passage. This disc is perforated in one position to form the full-way passage, and in three other positions it carries valves, any of which can serve to close the steam passage. The arrangement will be understood from Fig. 63. One only of these valves is, of course, used at a time, the others acting as spares or alternatives in case the first showing signs of leakage. We take it that these extra valves have been added partly owing to the general lines of the arrangement lending itself easily to their introduction, and that they need not be looked on as

essential. The a valve is operated by spanner acting on a square formed on a sleeve carried by the valve spindle. This sleeve works in conjunction with a cam fixed to the housing, and the first effect of operating the disc when opening the valve is to cause it to move slightly endwise, lifting the valve from its seat. The disc then rotates and brings the open port into the steam-way. When closing, the disc again moves slightly endwise and so remains until the valve has been rotated into the closed position, when the disc moves back and the valve seats itself. The two sides of the disc are connected so that it is balanced, and there is no end thrust due to steam pressure. A final point which





FIGS. 65 TO 67. MANŒUVRING VALVES FOR MARINE TURBINES; COCKBURN, LIMITED, CARDONALD, GLASGOW.

should be mentioned is that the perimeter of the fairway passage has a seating which lies on a valve face lying inside the face on which the valve proper works. The effect of this arrangement is that the main working valve face is entirely protected from the action of the flow of the steam when the valve is open.

Our next illustration, Fig. 64, shows a very simple but ingenious form of spanner which was shown by Messrs. Fastnut, Limited, of Beehive Wharf, Brentford, Middlesex. The spanner is known by the makers as the "World's Champion." At first sight it may appear that this spanner is simply intended to take four different sizes of nut, but actually its purpose is quite a different one, and is of a very ingenious nature. To describe the use of the spanner one may assume a nut has to be removed which fits the main jaw of the smaller end of the spanner. In by far the majority of cases the hardest pull is, of course, required for the first loosening of the nut, and after that, although the nut may be too stiff to be removed with the fingers, it still comes off with comparative ease. It is in this connection that the special spanner is useful. The nut is loosened by the main jaw of the smaller end in the ordinary way and the spanner is then reversed. It is so made that the short inner jaw of the other end is slightly larger than the main jaw already used. As a consequence, this short jaw may be used to screw the nut off its bolt after it has been loosened, and owing to the jaw being so short it may be slipped on and off the nut very rapidly. At the same time the larger outer jaw at the end which is being used serves as a guide to keep the spanner in position and prevent it slipping away from the nut altogether. As will be clear, the device is particularly useful for nuts in awkward positions in which a small stroke of the spanner is only possible.

A fine display of valves and turbine control gear was made by Messrs. Cockburns, Limited, of Cardonald, Glasgow, and Messrs. Aspinall's Patent Governor Company, of 10, Strand-street, Liverpool. The Aspinall patent turbine governor and forced lubrication control was fully described and illustrated by us in our issue of September 10 last year, and we need not re-describe it now. This governor is designed to work in combination with the Cockburn–MacNicoll bulkhead emergency valve, which was illustrated and dealt with in our previous article. Messrs. Cockburn also manufacture a manœuvring and emergency shut-off valve under the Cockburn–MacNicoll patents, and an example of such a valve is shown in Figs. 65 to 67 on this page. This valve, as illustrated, is also fitted with Hawthorn–Cockburn superheat control. The combination is particularly adapted for use on steamships in which no intermediate stop valve is fitted between the boiler stop and the manœuvring valves. The combined arrangement covering manœuvring and emergency valves is also less expensive than an arrangement involving separate emergency and manœuvring valves. The piping arrangement is also simplified.

The main ahead and astern manœuvring and emergency valves are to be seen, side by side, in Fig. 65. Either of these can be opened by hand-wheel through the screw and lever mechanism, best shown in Fig. 66. In the ordinary operation of either valve in this way the pin A bears against the arm B of the emergency operating bell-crank lever. The pin A is a few degrees over the vertical central line so that there is no possibility of the emergency control piston being pushed down instead of the valve being lifted. When closing the valve and hardening down, the pin A bears against the lug C. The valves can, of course, be regulated to give any desired amount of opening. The emergency control can be operated either mechanically or through the medium of the lubricating oil pressure. The latter arrangement is shown in the figures, the emergency control valve being shown in the lower part of Fig. 66. The oil pressure normally keeps the faces E of this valve and its seat in contact. A steam connection is also made through the hole F to the underside of the emergency pistons. Steam also passes to the top side of the pistons through the passage G and is prevented from leaking to atmosphere by the faces D which are in contact. When either the governors, hand control, or failure of the oil supply causes the pressure in the oil cylinder to fall the emergency control valve moves down until the faces H come in contact. This movement puts the emergency pistons to atmosphere on the underside, and the steam pressure above them moves them down so that they close the main valves from whatever position they may have been standing at. This action takes place through the lever mechanism and will be clearly followed from Fig. 66. The moving down of the emergency pistons breaks contact at the faces D and steam passes them, but it is prevented from escaping to atmosphere by the faces H being in contact.

When oil pressure is restored to the underside of the oil piston the emergency contact valve moves upwards until the faces E come in contact, and steam passes to the underside of the emergency pistons. The exhaust area past face D is much greater than the passage G so that although steam is being supplied through G there is no back pressure on top of the emergency piston which moves up and gives the main valve its original amount of lift. In this position the faces D come into contact and prevent further escape of steam to atmosphere from the top of the emergency piston. It will, of course, be understood that one or other valve is open, and although both ahead and astern emergency pistons are subject to control, it is only the piston of the valve that is open that operates. The shut valve should not be interfered with in any way. If desired, the emergency control can be arranged on the ahead valve only.

The Hawthorn–Cockburn superheat control, which has been worked out by Messrs. Cockburn in conjunction with Messrs. Hawthorn, Leslie and Co., of Newcastle, is intended to eliminate possibility of trouble owing to the sudden turning of highly superheated steam on to astern turbines which, under "ahead" conditions are revolving in vacuum, and also in view of the necessity of maintaining continuity of circulation in the superheat—elements under conditions other than those of steaming at full speed ahead. These conditions are met by arranging for the automatic mixing of superheated and saturated steam and supplying the mixture to the astern turbine. In the arrangement adopted, fixed proportions of saturated and superheated steam are passed. The superheated steam comes from the main steam pipe and passes through one beat of the valves, while the saturated steam comes from the boiler and passes through the other beat. The saturated steam connection is made at the left-hand side of the astern valve which lies to the left in Fig. 65. This, as will be seen, supplies the top beat of the double valve.

The lower beat is in connection with the superheated steam supply which enters by the flange shown to the top of Fig. 67.

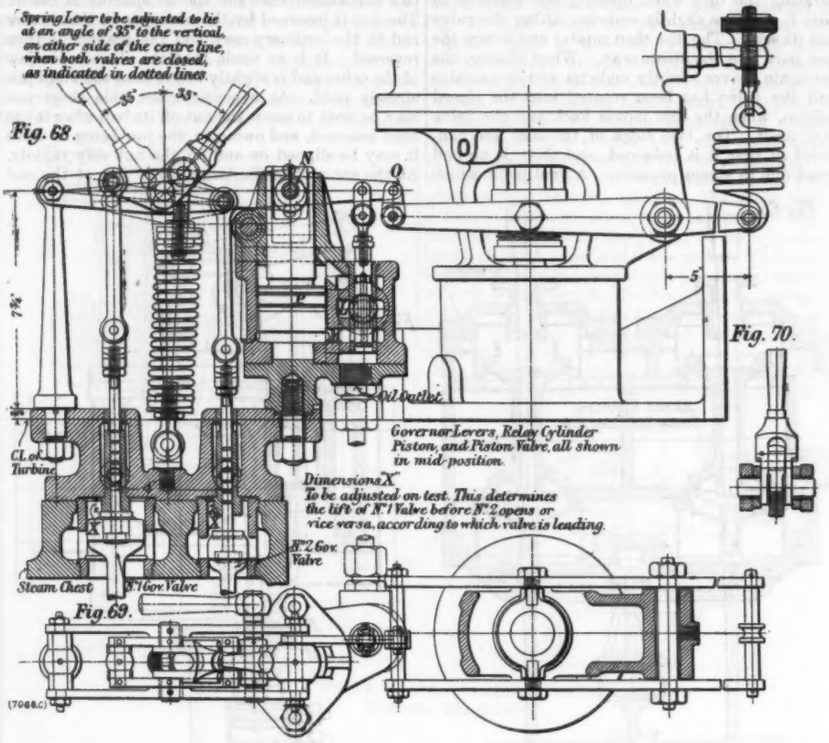
Although there were very many exhibits of interest with which we cannot now find space to deal, we would like before referring to our final illustration to refer to the superheater exhibit made by Messrs. H. and T. Danks (Netherton), Limited, of Netherton, Dudley. The superheaters were of Graham's patent type, which have advantages in the fact that eight tubes can be expanded through each manhole and the simple method of plugging tubes when necessary which is available. In one form of this superheater each tube is a unit which greatly facilitates packing for export and makes the superheater of special interest when shipping considerations come in. Although in no way connected, since we use the word shipping here, we may refer to the interesting display made by Messrs. Kitchen's Reversing Rudder Company, Limited, of Royal Liver-building, Liverpool. This rudder we have dealt with several times in the past, and it will be familiar to our readers, but we may refer to the full-sized model of the 48 in. Kitchen rudder fitted to the Spanish coaster Alca. The actual installation was described and fully illustrated by us in our issue of March 21 last. Another exhibit which caught our attention was the display of re-sharpened files made by Messrs. Vikings-Tenax, Limited, of 10, Vigo-street, W., and Brent Green, Hendon, N.W. We have no information on the method used by this firm except that we are assured that it is not a sand-blasting process. The results, however, are remarkable, and the treated files appear in every way equal to new, except that broken teeth are not replaced. The new process is applicable to files of any cut, rasps and Dreadnought files, and examples of each were shown.

In concluding this series of articles on the Olympia Show, we will deal with the very fine example of an auxiliary turbo-alternator set for ship's lighting, which was shown by the Metropolitan-Vickers Electrical Company, Limited, of Trafford Park, Manchester. Details of the governor gearing of this set are given in Figs. 68 to 70 annexed, while general news of the machine are given in Figs. 71 to 74 on page 478. The set is of 120 K.V.A., and the turbine is connected to the alternator through a reduction gearing, the speeds of the units being 7,500 and 1,000 r.p.m. The turbine is of the back pressure type and is a three-stage impulse machine with the first-stage velocity compounded. It is fitted with carbon glands, and has a multi-collar thrust bearing which determines the clearances. There is no importamt end thrust. A separate oil cooler is fitted and the oil pump is of a simple rotary gear type. The main gearing is of the double helical type and is contained in a separate gear case bolted to the bearing housing and the continuous bedplate. The pinion is coupled to the turbine spindle, and both the pinion and spindle are supported by two bearings. The low-speed gear wheel is made from a steel rim dowelled on a cast iron centre. One end of its shaft is connected with the governor gear worm drive through a flexible coupling and the other end to the alternator half-coupling. The wheel teeth are lubricated at the point of contact by oil spray pipes. The bearings of the high-speed turbine and pinion shafts are of the solid non-adjustable type with stop screws to prevent rotation. The low-speed gear and generator shaft bearings are adjustable.

Steam is admitted to the turbine through a combined stop and emergency valve which leads to the steam chest containing the governor valves which control the flow to the steam nozzles. Each valve is separately connected to a group of nozzles. The governor valves are of the balanced double-seated type and are operated by an oil relay. They are shown in cross-section in Fig. 68. The governor valves are controlled by a spring-loaded centrifugal governor which is driven from the low-speed gear-shaft through a worm reduction gearing. The governor controls a small pilot valve shown at L in Fig. 68. The chamber on which the letter L is placed in Fig. 68 leads to the oil pressure supply, while chamber M leads to the oil drain. In following through the operation of the gear it will be convenient to consider the action when some load is taken off the turbine, causing a slight increase of speed. The first effect of this will be to cause the governor weights to move outward and lift the pilot valve L, using N as a fulcrum. This will open the space under the piston P to the oil drain, and the piston will descend until the pilot valve is brought back to its central position by the levers, using O as a fulcrum. The reverse action takes place with a decrease in speed. The operation of the piston P, as will be clear from the figure, opens or closes the governor valve. The gear is adjusted so that these open in sequence. Up to full load the first governor valve is in operation, and for overload the second governor valve opens up a second group of nozzles.

GOVERNOR GEAR FOR SHIP'S LIGHTING TURBO-SET.

CONSTRUCTED BY THE METROPOLITAN-VICKERS ELECTRICAL CO., LTD., MANCHESTER.


Spring Lever to be adjusted to lie at an angle of 35° to the vertical, on either side of the centre line, when both valves are closed, as indicated in dotted lines.
35°
35°
Fig. 68.
N
O
P
L
M
Oil Outlet
Governor Levers, Relay Cylinder Piston, and Piston Valve, all shown in mid-position.
Dimensions X
To be adjusted on test. This determines the lift of N° 1 Valve before N° 2 opens or vice versa, according to which valve is leading.
C.L. of Turbine
N°2 Gov. Valve
Steam Chest
N°1 Gov. Valve
Fig. 69.
5
Fig. 70.
(7068.C)

NOTES ON NEW BOOKS.

It is not many years since an American firm wishing to erect works in England, sought to obtain designs and tenders from different bridge and roof building firms. The prices appeared so high that an investigation was made, which showed that there was no consistency whatever between the working stresses in different parts, and on inquiry the tenderers gravely announced that they thought it unnecessary to compute stresses in steel work of the character in question. There has been a great change in such matters since the incident in question, and this change has been hastened by the introduction of reinforced concrete, and by the passage of the London Building Act. Rules of thumb no longer meet the needs of the contractor, and there has been a corresponding increase in the number of books written to assist the work of the computer. A handy and comprehensive collection of tables and formulas, compiled to this end by Mr. E. S. Andrews, B.Sc., has been issued by Messrs. B. T. Batsford, Limited, of 94, High Holborn. The book is entitled "*The Structural Engineer's Pocket Book*," and is priced at 18*s.* net. The title is perhaps rather more comprehensive than the contents justify, as the subject of reinforced concrete is omitted, having been dealt with by the author in a separate volume. The designer of steel work will, however, find his needs very adequately met, though we most emphatically repudiate the author's views on the subject of secondary stresses, which are in no way justified by experience, and if carried to their logical conclusion would involve the construction of the compression chord of a braced girder as a series of independent struts; since in this way only could secondary stresses be eliminated at the panel points, as the author says they should, or else be allowed for. As a matter of fact, so far from designers making any "allowance" in their calculations for such secondary stresses as must arise here, they invariably assume that the chord is actually strengthened by being continuous over the panel points. It is, indeed, not a little curious that the very men who follow this practice so often get "scared" at the existence of secondary stresses elsewhere, and demand, like Mr. Andrews, that they must be allowed for or eliminated. This criticism apart, the work meets remarkably well the needs of the designer of structural steelwork. There are over 150 tables and numerous illustrations, including almost complete drawings of certain types of truss.

The suspicion, usually well founded, that a book published by a manufacturing concern is merely a more or less subtle form of advertisement for their particular products need not be held in the case of "*The Cochran Book of Oil Firing*," issued by Messrs. Cochran and Co. (Annan), Limited, of Annan, Scotland. This firm's speciality is, of course, a vertical multi-tubular boiler, and although the application of oil-firing to this boiler is dealt with among others, the subject is discussed in a sufficiently general manner to render the book serviceable to users of boilers of practically all types. Both land and marine applications are referred to in detail, and a large amount of information on accessories, such as storage tanks, tank fittings, heaters, filters, pumps, &c., is included, together with descriptions of different systems and practical instructions for working. The tables giving pump capacities, fuel costs for coal and oil, compositions of fuel oils, oil consumption, and tank capacities are also useful features. The subject matter, which is fully illustrated, has been prepared by Mr. W. K. Wilson, B.Sc., Wh., Ex., and the price of the book is 4*s.* 6*d.* net.

It is common knowledge that the governing of water turbines is complicated by the necessity of avoiding dangerous water hammer in the supply pipe. Approximate mathematical theories of the genesis and propagation of the wave of pressure characteristic of this phenomenon have been worked out by many engineers, but their results have in general not been either specially precise or particularly convenient. In 1903 and 1904 Signor Lorenzo Allievi, an Italian engineer, took up the subject afresh, and in a series

of papers since issued has developed what is probably the most complete presentation of the theory from the mathematical standpoint yet published, and at the same time has established a "law of comparison" between different conduits which greatly facilitates the practical application of his theoretical results. His papers have been translated into French and published in book form, under the title "*Theorie du Coup de Bélier*," by Messrs. Dunod, of the Quay des Grands-Augustins, Paris, at the price of 6 francs. An impulse applied to an elastic system gives rise to a wave of stress which has a definite speed of propagation, dependent on the elastic properties of the medium. In the case of a long pipe it is necessary to take into account both the elasticity of the water and that of the pipe, and in this way Signor Allievi demonstrated that the rate of propagation, which he denotes by a, is given by the relation—

$$\frac{1}{a^2} = \frac{\omega}{g}\left\{\frac{1}{\epsilon} + \frac{1}{E}\cdot\frac{D}{e}\right\}$$

where ω denotes the density and ϵ the bulk modulus of the fluid, whilst E is Young's modulus for the pipe material, D its diameter, and e its thickness.

Substituting the appropriate values of these quantities in the above formula, he finds that a (in metres per second) is given by the equation—

$$a = \frac{9900}{\sqrt{48.3 + K\frac{D}{e}}}$$

where K = 0·5 for pipes of steel and wrought iron and is unity for cast iron pipes. The value of a commonly lies between 600 to 700 metres per second for large pipes having thin walls, and between 1,200 and 1,300 metres per second for thick-walled pipes of small internal diameter. The equation giving the pressure at any point x of the pipe at any time t is analogous to that met with in the theory of the vibration of an elastic string, and, as in that case, when the length is infinite, the impulse passes along as a solitary wave. With a finite length, however, a reflection occurs at the reservoir end of the pipe, and in certain cases, which are fully discussed by the author, the interference of the two waves gives rise to resonance effects. The law of comparison for different pipes involves two parameters ρ and μ, which, taken together, completely define the phenomena. Of these, ρ is equal to—

$$\frac{a\ v_0}{2g\ y_0}$$

where v_0 denotes the normal velocity of flow and y_0 the normal head at any point. It is this head which stretches the walls of the pipe and measures accordingly the potential energy stored up in them. The other parameter, μ, is the half period of the oscillations, and is equal to $\frac{2L}{a}$, where L is the length of the pipe. Based on these considerations, the author has developed a graphic method of treating the problem, which greatly facilitates the practical application of his theory.

The extent to which the small internal-combustion engine has entered into the life of present-day communities will be appreciated from the fact that to-day, of over 150,000,000 h.p. in service, 130,000,000, or 87 per cent. of the total, is developed in engines of less than 50 h.p. each. In all spheres of activity the changes resulting from the introduction of this handy, cheap and compact prime mover, are enormous, chiefly because of the practicability of this type of plant being handled by the owner alike as regards operation and simple overhaul. With yachting and boating, the certainty and regularity conferred upon this sport by the fitting of a petrol or paraffin engine to various types of craft is in keeping with the requirements of modern times. Fortunately, concurrently with these developments, there has become available a large amount of literature serving to initiate the novice, to give enlightenment to the enthusiastic amateur and to help to keep the expert *au fait* with development and the introduction of novelties. In this sphere of utility, where all types of internal-combustion engines are concerned, the Temple Press has played a leading part. The eighth edition of "*The Motor Boat Annual*," just issued by them at 3*s.* net, describes in a concise way the leading characteristics of various classes of craft, giving many dimensions to guide those contemplating becoming owners, elucidating the leading principle of the design and construction of such craft, as well as the fundamentals of internal combustion, both for petrol and paraffin engines of the two- and four-stroke types. A valuable revision of the previous issue concerns outboard motors which are now being so extensively fitted to dinghies, &c., and a section dealing with aerial propulsion has been added. The subjects of carburation and ignition are fully dealt with and comprise about a quarter of the total contents. Propellers, installations of machinery, piping, reverse gears, &c., are also touched upon. At the end of the volume is included a supplement dealing with sailing and navigation rules and regulations. The whole forms a useful manual of 178 pages, and is compact by virtue of the illustrations, of which there are a good number, these being sufficiently large, but not more so than is required clearly to illustrate the text.

It is probably the fact that the achievement of man's desire to fly was so long delayed, coupled with admiration for the courage and persistence of the early experimenters, which renders the development of aviation such a particularly fascinating study. Whatever may be the reason, the history of the subject appears to be of more general interest than that of any other branch of applied science. It is, however, scattered about in numerous obscure and more or less inaccessible publications, which even the most earnest student of aeronautics would find too troublesome to consult, even if he could spare the time necessary for the work. The student, as well as the general reader, will, therefore, welcome "*A History of Aeronautics*," by Mr. E. C. Vivian and Lieut.-Col. W. Lockwood Marsh, O.B.E., in which the available information has been collected and arranged consecutively in an interesting and attractive manner. More than half of the work deals with the evolution of the aeroplane from legendary times to the present day, while a separate section, contributed by Lieut.-Col. Marsh, gives a more detailed explanation of the progress in aeroplane design from 1903 to 1920. Two remaining sections are devoted to aerostatics and engine development, the former dealing with early and modern dirigibles and kite balloons, and the latter with various types of power units, ranging from Maxim's steam engine to the Napier "Lion." The text is illustrated by numerous reproductions from old prints, and from early and recent photographs. Some of the old machines illustrated are remarkably similar in appearance to those of modern construction, and the fact that if the former rose at all they generally crashed with fatal results to the inventor, will doubtless help the reader to appreciate the true value of the work of the Wright brothers. The publishers of the volume are Messrs. W. Collins, Sons and Co., Limited, 48, Pall Mall, S.W.1, and they, as well as the authors, must be congratulated on a very creditable production. Its price is 30*s.* net.

A little brochure by Lieutenant Harold Atkinson, R.N.V.R., entitled "*Marine Diesel Engine and Semi-Diesel Engine, Operation and Management*" (Messrs. E. and F. N. Spon, Limited, price 2*s.* net), will be especially valuable to young sea-going engineers, who already possess practical experience of steam propelling machinery, and are now desirous of completing their engineering education by gaining a practical knowledge of the running of internal-combustion engines. The author has dealt in plain understandable language with the many important details to which engineers on internal-combustion engined ships should devote close attention. His own practical experience, which has obviously been of a wide and varied character, has enabled him to foresee the difficulties with which the young engineer is faced, and each of those difficulties is dealt with in detail. It is difficult to draw special attention to any particular section of the book, as each paragraph, from the opening injunction regarding fuel supply, down to the paragraph which deals with the care of, and attention to, auxiliary machinery, dovetails one into the other, producing a complete series of timely warnings and injunctions. The important point of indicator diagrams, to which the author devotes considerable attention, is dealt with in Chapter V of this book. Typical indicator cards are reproduced and detailed observations made upon them. The author lays special stress on the importance of taking indicator diagrams as the readiest means of diagnosing any irregularity and enabling the engineer to ascertain and apply the remedy. The book is completed with an index, and is of a convenient size. A copy should be in the possession of all sea-going engineers, to whom it may be highly recommended.

PERSONAL.—Mr. Frank H. Brunt, M.Inst.C.E., has removed from 100 to 121, Victoria-street (telephone number, Victoria 8477).—Mr. Leonard Andrews informs us that having concluded the work on which he has lately been engaged for Messrs. Johnson, Matthey and Co., he intends to open an office at 104, Victoria-street, S.W. 1, with a view to practising as a consulting engineer. —Messrs. Coode, Matthews, Fitzmaurice and Wilson, 9, Victoria-street, S.W. 1, inform us that from October 1, Mr. H. H. G. Mitchell and Mr. A. G. Vaughan-Lee will be taken into partnership in the firm, whose name and address will remain the same as before.—The Spearing Boiler Company, Limited, state that they moved into new and larger offices yesterday, and that their address will in future be No. 20, Kingsway, London, W.C. 2, and their telephone numbers Holborn 5740 and 5741, with telegraphic address Arcturus, Estrand, London.

THE TEMPLE SUBMARINE STUD DRIVER.

On Tuesday last an interesting demonstration of a new tool which may have a large field of usefulness in connection with submarine salvage operations was given at Caxton Hall, by Mr. Robert Temple, the inventor of the apparatus. The function of the tool is to fix studs into ships plates or other steelwork under water, so that patching plates or attachments for lifting may be bolted on. The studs used at the demonstration were of tool steel, tempered to a dark blue colour, one end being bluntly pointed after the manner of the old pattern of service projectile, and the other end having a screw thread cut on it. They were about 3½ in. long and ⅝ in. diameter. These were shot into a ⅞ steel plate from the muzzle of a "gun" held in contact with the plate, and pierced the latter so that about an equal length of the stud was left projecting on both sides. The metal of the plate was splashed up around the stud at entry and exit, the stud appearing quite uninjured, although it was so firmly held in the plate that we were assured that the thread, would strip before it could be withdrawn. The operation of driving the stud was instantaneous. Several were driven in a crowded room through a piece of ⅞ steel plate, and the noise was hardly more than that of an air gun.

The Temple gun resembled a pneumatic hammer but with the handle crosswise at the end, like that of a spade. Pressure of the muzzle of the gun against the work caused the barrel to telescope slightly against the action of a spring, and a striking pin then detonated a cap and fired the explosive charge. This, we understood, might consist of any ordinary propellant explosive, of which about the same quantity was used as in a standard 0·303 rifle cartridge. The charge was contained in a cylindrical metal cup attached to the rear end of the stud. Before firing, the cup holds the stud centrally in a chamber of the gun, there being about a quarter of an inch clearance all round the stud. The forward end of the chamber is closed by a renewable copper disc which shuts it off from the barrel portion, the latter being an inch or two long only. On firing, the stud and cup go forward together until the stud has passed through the disc, but as the cup, being of considerably larger diameter than the barrel, cannot go through the disc, it is torn off the stud by the shearing of its connection. The force necessary to do this is said to neutralise the "kick" of the gun, which otherwise would be unmanageable.

We were informed that studs could be driven into solid steel by the Temple gun, and that two ⅝ in. plates could be pinned together by studs shot through them. It was also stated that a pin of only ½ in. diameter could be driven through a 1¼-in. plate. When a patch plate has to be fastened to the side of a vessel under water, this plate is first drilled and well countersunk. The countersunk face is placed against the ship's side, and studs are shot through the holes, the countersink allowing room for the splash of the metal, which otherwise would force the plates apart. The plates are then bolted together by nuts put on the projecting screwed ends of the studs. The driver locates the gun by a small wooden plug inserted in the end of the barrel, which enters the hole in the patch, and so holds the gun in position. After a stud has been fired, the gun is sent to the surface for re-loading, which is only a matter of a few minutes.

The Temple process of fixing studs is certainly a very remarkable one, and the work done by it appeared to be successful and uniform. The plate into which the studs were driven required no solid backing of any kind, and it was stated that it could be held in the hands without discomfort. Studs were inserted, at the demonstration, into plates lying in a box of sand, and also placed in a tank full of water. The process is in the hands of the Temple Cox Research Company, Dacre House, Dean Farrar-street, Westminster, S.W. 1.

BRITISH STANDARD SPECIFICATION FOR TRAMWAY AXLES.—A British Standard Specification for Tramway Axles (No. 102–1921) has recently been published by the British Engineering Standards Association, and follows very closely the lines of the revised British Standard Specification for Railway Carriage and Wagon Axles (with analysis) which is included in Part I of the new edition of Report No. 24. A percentage of 0·5 of phosphorus or sulphur is permitted in the steel as in the case of the railway axle specification, but for the manufacture of tramway axles, no particular process of steel-making is specified. Falling weight, tensile and cold bend tests are required, the latter being for use only where the order is for a number of axles under 15, when it is to take the place of the falling-weight test. A diagram is included illustrating the method of performing the cold bend test. Normalising (of which a definition is given) or oil-treating is specified, the choice to lie with the purchaser. The specification may be obtained from the Secretary of the British Engineering Standards Association, whose offices are at 28, Victoria-street, S.W. 1, or from Messrs. Crosby, Lockwood and Son, Stationers' Hall-court, E.C. 4, price 1*s.* or 1*s.* 2*d.* post free.

INDUSTRIAL NOTES.

In the official statement issued after the visit of some of the mayors of London boroughs to the Prime Minister at Gairloch, which event took place as we went to press on Thursday of last week, Mr. Lloyd George said that the central government could not shoulder the burden of unemployment relief alone. He hoped for co-operation between the Government, local authorities, traders, bankers and organised labour, and Parliament would also be consulted on the matter. In the meantime boards of guardians would be assisted to obtain loans, for meeting which the guardians would be responsible.

During the week the subject has continued to receive the attention of the Government. The Cabinet Committee has been enlarged by the addition of several members, but at the time of going to press the new proposals had not taken sufficiently definite form enable any official statement to be made. The impression seems to be that the Prime Minister's plans include an export credit scheme, which, presumably, would be a modification of the one already at work, but which has received only scanty support.

Concurrently with the Premier's Gairloch statement the Parliamentary Committee of the Trades Union Congress, and the Executive Committee of the Labour Party, issued a joint manifesto taking objection to the Unemployment Committee's original relief proposals which, as we reported last week, involved the raising of loans by local authorities. Instead of these the Labour plan is that, for revenue-producing works, the Government should pay 75 per cent. of the cost, and lend the other 25 per cent. free of interest for three years, while for non-revenue works the direct State contribution should be 90 per cent., with a loan of the balance for five years, free of interest.

Incidentally we may here again refer to Mr. Lloyd George's speech at Gairloch, in which, when speaking of the mayors' arguments that the ratepayers had got to the end of their tether, he pointed out that the same argument might be used for the income tax payers.

The main plank of the Labour programme indicates a distinct advance in thought, and as such can be heartily welcomed, though it may not be expected to receive cordial approval after our experience of recent years. The manifesto recognises the fact that relief work of the ordinary type is unsatisfactory, and that greater benefit would accrue from improved trading. It is true that it lays considerable stress upon stimulating home trade which, however, it assists in increasing demand, is secondary in importance to the primary necessity for improved export trading.

We believe this to be the first important occasion when export trading has been officially admitted by Labour to be a vital economic factor in our existence, and for this fact we welcome the statement. When, however, we come to the method by which the plan is to be worked out we cannot go forward with the proposers. The suggestion is that the Government should place substantial orders for textiles and agricultural machinery, itself exporting the products on credit to continental countries in need of them, dealing with other governments, co-operative societies, and other organisations—doubtless a reflection of the constant hankering on the part of Labour after trade with Russia. We are pleased to note that further Government trading is deprecated by members of the Cabinet Committee, it being pointed out that the large stocks of Government goods remaining to be disposed of as a result of the war have already dislocated many markets. Chambers of Commerce are also opposed to this Labour proposal.

It is claimed by Labour, with some justice, that their scheme would stimulate home and foreign commerce, that it would save enormous sums in direct relief, is not open to the objection of lowering the morale of the people, and would keep machinery in order ready for a revival of trade. We have certainly advanced a good deal when it is recognised that ordinary relief works do not materially improve the situation, and that the country would stand to benefit much more if relief could be combined with trade, and above all with export trade. The manifesto, however, makes the mistake of laying altogether too much stress on the maintenance of the home market which it says cannot be kept at a prosperous level if wages are reduced. It is the fallacy of a prosperous home market which has plunged us into our present difficulties, and the situation would be more surely eased by economy and thrift at home than by maintaining the spending power of the masses at a fictitious level. With regard to the export proposals the manifesto assumes that there is a market abroad for our products. At the moment this unfortunately is not at all certain, with our present manufacturing costs. The one-sided view of Labour is disclosed in this connection. Mention is made of the point that under the proposed scheme it might be necessary for employers to forego their normal profits. At a time when many manufacturers have been in vain making efforts to keep trade together by foregoing all profits and have failed to prevent it slipping away, owing to high labour costs, such a remark shows that there is still much enlightenment needed in the quarters from which the manifesto emanates. Not a word appears regarding the lowering of production costs by greater productive effort, the only sound basis on which healthy trade can be revived, and competition in foreign markets successfully faced. Latterly, due at least in a degree to high wages coupled with low effort, we have not been in a position to compete abroad. The inevitable result, brought largely by Labour upon itself, is now to be seen around us.

At a meeting of the Scottish Council of the Labour Party held on Saturday last, a resolution was passed giving a scale of maintenance for the unemployed in the absence of the provision of work. The principle of adequate maintenance in the absence of work was also embodied in the Labour manifesto referred to above. The question of where ultimately the necessary funds are to come from was not thought worth consideration, but at the Scottish meeting Mr. F. W. Jowett made an attack upon the Government for loading the country with debts upon which heavy interest had to be paid. For his own purposes he specifically referred to war debts and the possible cost of further extending credit by Government backing, which latter, by the way, is practically equivalent to Labour's own programme, though the idea that actually favours is direct Government trading, instead of merely State financial backing. It is unfortunate that Mr. Jowett's vision is not clear enough to reveal to him the fact that maintenance without productive work must in the end result in adding to the heavy interest burdens he spoke of just as surely as the factors which he actually chose to mention, or the raising of loans for Government trading, or for backing credit schemes.

A number of London Members of Parliament met on Monday last to consider the question of unemployment, Mr. Macnamara and Sir Kingsley Wood attending on behalf of the Government. A committee was elected to consider practical proposals. Information has been promised by Government departments; a further meeting will be held on Monday next.

A circular issued by the Ministry of Health laying down the procedure to be adopted in connection with the Unemployment Committee's relief proposals, states that the rates for unskilled labour should, for a probationary period of six months, be appreciably lower than the full district rate of the area. It further lays down that workmen so taken on must remain on the Labour Exchanges books and will be required to take other suitable work if and when the exchanges are in a position to offer it. We trust that every effort will be made to work the latter provision in a thoroughly effective manner. With regard to the general scale of relief pay it is interesting to note that last week a strike was reported at Walsall of some of the local authority's employees, who found that they were earning less for a full week's work than men in receipt of unemployment relief were drawing.

An experiment which promises to be of some interest is to be made at the Dunniker Colliery, Fifeshire. This colliery was to have been closed last Saturday, but as a result of a meeting of the miners employed it was resolved to give a month's trial to the owner's condition for continuing to work the mine, namely, that the individual daily output should be increased to 30 cwt. The Fife Coal Company state that the daily output of their men is only 15 cwt. compared with 35 cwt. pre-war, and that they lose 10*s.* per ton mined.

The Scottish Printers have, it is reported, balloted in favour of the acceptance of the employers' proposals that wages should be reduced by 5*s.* per week for adult workers as from October 1, and a further 2*s.* 6*d.* from the beginning of 1922. At a meeting at Stationers' Hall on Wednesday of the Council of the Federation of Master Printers, it was stated that the terms submitted by the National Wage Basis Committee had been in all cases accepted by the Trades Unions. The reduction of 5*s.* per week will be made from this week.

A serious situation has arisen in the South Wales Coal Industry as a result, it is stated, of an error in accountancy on the part of the owners. The disorganisation which has resulted is referred to in our Notes from the South-West, in another column.

The deadlock in the engineering and shipbuilding trades, with regard to the abolition of the war bonus, has unfortunately not terminated, and an appeal has been made to the Ministry of Labour. At the time of going to press no further developments have been made public, the Minister being expected to make known his decision shortly, after which it is stated a ballot will be taken if necessary. The difficulty has arisen owing to the men's contention that the bonus was awarded to meet the high cost of living, while the employers hold that it was introduced for the benefit of the skilled men, who, under war conditions, frequently found themselves earning less than the dilutees they trained.

The Mossend Steel Works, employing 1,400 men, and the Glengarnock Steel Works, employing 4,000 men, have both been closed owing to lack of orders.

Meetings were held at many Scottish centres last week-end to discuss the railway companies' proposals with regard to new scales of wages. The companies contend that in the light of present traffic returns it is impossible to carry on with wages at the high scale of the award of June of last year. Their main proposals are that the increases then granted should be cancelled, and that the special rate for night duty should cease. There was a good deal of rather violent language used. Negotiations are still in progress, and it is hoped a conclusion will be reached without a cessation of work.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Future of the Mines.—Addressing the shareholders of the Sheepbridge Coal and Iron Company at the annual meeting in Sheffield, Lord Aberconway gave some striking statistics of the result of the coal strike. The output of the Sheepbridge Colliery, he said, was down during the year 712,000 tons, and the loss in wages to the men was something like 700,000*l.* Had that money been invested by the men they could have bought a controlling interest in the whole of the Sheepbridge Company. A coal-getter's wages in 1921 was 23*s.*, as compared with 12*s.* in 1913, while the output per man for all men employed was 158 tons in 1921 as against 372 tons in 1913. It was no use the men now going to the owners and asking them to work unprofitable districts. They had joined in smashing the coal trade, taken out the safety men and allowed the pits to be flooded, and must now abide by the result. We had lost temporarily the whole of our foreign markets. Blast furnaces, rolling mills, iron foundries, steel foundries, steel rolling mills, shipyards and engineering works, if not at a standstill, had been badly hit, and probably taken altogether were not working more than a quarter of their normal capacity. He saw no prospect of improvement for many months to come unless the men agreed to modifications on all existing customs—price lists and restrictive conditions which had hampered them in the past.

Iron and Steel.—A most interesting summary of the position of the iron trade was, in addition, given by Lord Aberconway. Iron works, he stated, were practically dormant all over the country. The pig-iron trade had fallen off in March, and since then practically every blast furnace in the country had been closed down. Out of 500 blast furnaces built in the British Isles only 46 were in blast in August, and very few had been started since. High prices of coke and other raw materials, and the high wages of iron workers had made it almost impossible to produce pig-iron to compete with the French and the Belgians. They could not possibly make pig-iron in Derbyshire for less than 6*l.* 10*s.* per ton, while Belgian pig-iron could be delivered at Middlesbrough at 4*l.* 10*s.* per ton, and in the Midlands for 5*l.* 7*s.* 6*d.* per ton. Bar iron followed in the wake of pig-iron, but in that respect there would be reductions owing to the sliding scale, which would enable them to carry on. Foundries had been busy, but the demand had fallen, and he did not know when it would revive. Though somewhat pessimistic these views fairly summarise the situation. Employers are having a most anxious time, and in many instances are finding the financial strain almost unbearable. Of course, the slump has not hit everyone alike, and in individual cases one heard less gloomy reports. A fair quantity of orders had recently been placed for mining steel, crucible steel, and steel products by the Colonies and South America. Substantial inquiries were coming in from South Africa, Australia and even South America, and more business could be done in these directions if manufacturers were in a position to give the long credits frequently demanded. The heavy steel branches remained in an almost stationary position. The open-hearth furnaces continuing to work steadily did not number one-third of the total. The crucible trade as a whole was weak, though some houses had a fair number of orders for mining steel for the Colonies. A few orders, backed up by gold in London, had also been received from Russia for steel saws, files and tools. The trend of prices continued downwards.

South Yorkshire Coal Trade.—Business on the coal Exchange continues on the quiet side, sellers being more plentiful than buyers. There is little change in the situation as reported last week. The home demand for steam coal is far below the normal although there is a slight improvement to report in this respect. Railway companies are getting their reserves built up and are not now pressing for supplies. Cobbles and nuts are on the weak side, although the demand for bunkering has improved. Exports are still on the small side, due to some extent to the severe competition of the Tyneside collieries. Gas fuel is again moving more freely. Small

fuels are steadier, being increasingly used for coke-making purposes, and as more furnaces are put into operation the demand will further improve. After a long period of depression the market for house coal shows signs of hardening. Many householders who have hitherto been holding off are placing stocking orders; and as the severe weather approaches these will increase rapidly. Quotations:—Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 32*s.* to 33*s.*; Derbyshire small nuts, 29*s.* to 30*s.*; Yorkshire hards, 31*s.* 6*d.* to 32*s.* 6*d.*; Derbyshire hards, 30*s.* 6*d.* to 31*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; nutty slacks, 16*s.* to 17*s.*; smalls, 5*s.* 10*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Notwithstanding continual acute scarcity of No. 3 G.M.B. Cleveland pig-iron, values of that commodity tend downward. Makers agreed on minimum of 120*s.* for home purposes is as much as home buyers will pay, and it is reported that the few transactions recently put through have been at that figure. The f.o.b. export quotation of No. 3 is 125*s.*, but there is little inquiry from abroad. Continental pig-iron is still arriving in this district in fulfilment of contracts made at substantially below what producers here can offer. The lower qualities of Cleveland pig-iron are so plentiful as to be quite a drug on the market and makers are anxious to reduce their large stocks by selling at their fixed minima of 119*s.* for No. 4 foundry, 117*s.* 6*d.* for No. 4 forge and mottled, and 115*s.* for white iron.

Hematite.—Output of East Coast hematite is in excess of requirements, and manufacturers are keen to book orders. Home and export quotations are identical. Nos. 1, 2 and 3 stand at 130*s.* and No. 1 is put at 132*s.* 6*d.*

Foreign Ore.—There is practically nothing doing in foreign ore, only an occasional cargo being disposed of. Business is almost entirely confined to the arrangement of deliveries under old contracts. Nominally best rubio is 28*s.*

Coke.—The situation as regards coke shows little change, but fall in values at an early date is confidently anticipated. Second-class Durham blast-furnace coke is now offered at 33*s.* delivered, but best sort is still 35*s.* Local consumers are not prepared to pay anything above 30*s.*

Manufactured Iron and Steel.—The few small orders obtainable in the various branches of finished iron and steel are only sufficient to keep works going intermittently. Sheets are down 20*s.*, and fall in other descriptions is looked for. To home customers, common iron bars are 14*l.*; marked bars, 18*l.*; steel ship, bridge and tank plates, 14*l.*; steel angles and joists, 13*l.* 10*s.*; steel hoops, tees, flats and heavy sections of rails, 14*l.*; rounds and squares, 13*l.*; steel billets (medium), 10*l.* 10*s.*; steel billets (hard), 11*l.*; black sheets, 15*l.* 10*s.* to 16*l.*; corrugated galvanised sheets, 19*l.*; and fish-plates and sleepers, 19*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A depressed feeling still prevails in the steel trade of Scotland, but this may pass off to some extent with the better prospect in the shipbuilding industry. The outlook in the latter has improved slightly through receipt of instructions to proceed with the construction of several contracts which were recently stopped owing to trade conditions. In the meantime, however, there is very little business passing in home steel, and order books are extremely light, and although the inquiry keeps up, the resulting business is far from satisfactory. The difference between the local and the Continental prices is much too high from the buyers' point of view, and in consequence many orders are going foreign. Every endeavour is being taken to reduce the cost of production, but managements are finding no little difficulty when trying to make a saving so as to get prices of their products reduced. Plant all over is only being partly employed, and the outlook for the last quarter of the year is not very bright. Prices are without change and are as follow: Ship plates, 14*l.* per ton; boiler plates, 19*l.* per ton; sections, 13*l.* 10*s.* per ton; sheets, $\frac{1}{4}$ in. to $\frac{1}{2}$ in., 15*l.* 5*s.* per ton; all delivered at Glasgow stations.

Malleable Iron Trade.—No improvement of any kind can be reported in connection with the West of Scotland malleable iron trade, and there is very little work on hand. The cut made in prices last week has not been very fruitful yet, as only a little business has been booked, but makers are hopeful of fixing up a lot more orders before any further reduction is necessary. The latter will come along all right later, but not until costs have come down considerably. "Crown" bars are now called 14*l.* per ton, at Glasgow stations, but against this the Continental makers name from 8*l.* 5*s.* to 8*l.* 10*s.* per ton. Export trade is very quiet, but when any lines are on offer local producers are now free to compete individually for the business.

Scottish Pig-Iron Trade.—Although the Scottish pig-iron trade continues very quiet there is certainly a rather better tone prevailing, but more than that is required to keep the furnaces going, as every ton produced now and put into stock will probably have to be sold at a lower margin—perhaps at a loss—later on. The cost per ton is too high at present, and although prices are easier this week, on-cost charges have not come down proportionately. The local demand is very poor as buyers are sitting on the fence awaiting what they think will be the rock-bottom level. They will probably require to wait a bit longer than they expect, however. The export side of the trade is miserably quiet still, and very little business is passing in that direction. Home orders booked recently are a shade better in tonnage, and inquiries this week show an improvement. The current prices may be taken as follow: Hematite, 7*l.* 15*s.* per ton, delivered at the steel works; foundry iron, No. 1, 8*l.* per ton, and No. 3, 7*l.* 15*s.* per ton, both loaded into trucks at makers' works.

NOTES FROM SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Business has been driven to a virtual standstill, and the market upset and dislocated by news that the Welsh coalowners are liable for a much higher percentage of wages than was expected. Under the terms of the national strike settlement it was provided that in any district in which the wages, calculated in accordance with the permanent principles, are less than the wages payable under the maximum reduction, ranging up to 3*s.* per day in September, the difference shall be met by the owners in that district during September to the extent of the aggregate net profit realised by them on the district ascertainment for July. At the beginning of the month the Welsh coalowners were informed that the proportion of their wages bill which they had to bear on the 1915 standard rates in September would be 46·34 per cent. on those rates. This figure was accepted as in accordance with the terms of the agreement, but the owners have now been informed that their proportion should have been 97·57 per cent. The effect of this is to increase the owners' liability by from 5*s.* to 6*s.* per ton, and as many of the collieries were already selling and had sold their outputs at a loss, based on the lower percentage, the addition of 5*s.* to 6*s.* per ton was a very serious matter, and in the aggregate represented a liability of about 600,000*l.* The importance of the matter will be realised when it is mentioned that directorates were in many cases hurriedly called together to consider the position, and these in a number of instances decided to immediately close their pits pending further developments, and accordingly notices were given to some thousands of men terminating contracts until further notice. In other cases colliery salesmen withdrew all quotations, while a number increased their prices from 1*s.* to 5*s.* per ton, though some continued to carry on at the old rates. Business, however, was virtually at a standstill, as buyers generally refused to pay the higher values demanded, except for small lots for boats completing, preferring to await the result of negotiations which have been opened between the coalowners and the Mines Department of the Board of Trade. What the outcome of these negotiations will be it is impossible to forecast. In some quarters it is believed that the Government will help the owners out of their difficulty rather than see thousands of men thrown out of work and add to the total of unemployment pay, while others think that the Welsh owners will be left to make the best of it. Meanwhile business is held up, and it is likely to remain in a parlous condition until the matter is decided. Exports of coal as cargo from South Wales last week totalled 378,000 tons, compared with 419,000 tons in the preceding six days. A feature of the shipments to individual countries is the fact that the quantity sent to South America—62,000 tons—was nearly double the quantity sent in the previous week, and almost three times the volume of shipments five weeks ago.

Iron and Steel.—A few more tin plate mills have come into operation during the past week, and prices are slightly easier at from 20*s.* 6*d.* to 22*s.* per standard box. Inquiries generally show improvement, especially from the Continent. Galvanised sheets are unchanged at 19*l.* for 24-gauge corrugated in bundles, and 20*l.* for flats. The scrap market showed more firmness with heavy steel scrap at 60*s.* to 70*s.*, and good machinery scrap from 5*l.* to 6*l.*

UNIVERSITY COLLEGE, LONDON.—A programme has been published of special arrangements and public lectures for the first term of the 1921–22 session of University College, of the University of London. The list is too long for publication, but we may note that among others will be found several of more than common interest to our readers. For instance, Dr. G. B. Jeffery will give a lecture on October 10, at 5 p.m., on "The Einstein Theory of Relativity." On November 14, Professor E. G. Coker will lecture on "Photo-Elasticity," and on November 28 Mr. A. J. Walmisley will lecture on "Geometry for Engineers." The particular lectures referred to are open to the public without fee or ticket. The full programme may be obtained from the secretary.

A TURBINE SHUNTING LOCOMOTIVE.—Our attention has been drawn to the fact that the Società Officine Meccaniche, of Milan, constructed a small steam turbine locomotive as long ago as 1908. This engine has been at work shunting since that date to the present time. It is a four-wheeled engine without coupling rods, and was designed by Professor Guiseppe Belluzzo, of the Technical High School, of Milan. It has four small turbines placed outside the frames and gearing with tooth rings fixed to the outside of the wheels, rather above and ahead of the axle centres. Two turbines are provided for movement ahead, and two for reverse. It is stated that after long experiments on condensing plant, designs for a 1,500-h.p. locomotive have been prepared on the expectation of large fuel economy.

NOTICES OF MEETINGS.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, October 3, at 5.30 p.m., in the Apartments of the Geological Society, Burlington House, W., when a paper will be read on "The Winning of Tidal Lands in British Guiana," by Mr. Gerald O. Case, A.M.E.I.C., Assoc.M.Am.Soc.C.E., M.S.E., Consulting Engineer to the Government of British Guiana.

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, October 8, at 6.30 p.m., in the Assembly Rooms of the Cycling Club, Cavendish-street, Mr. W. M. Selvey, Sheffield, on "Heat Balance of an Electric Power Station." Chair to be taken by the president, Mr. Robert Hudson.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Friday, October 7, General Meeting at the Victoria Hotel, Manchester, at 5 p.m., when a paper entitled "Notes on Axle Boxes and Horn Blocks," by Mr. A. E. Kyffin, will be read and discussed.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 7, at 8 p.m., at Caxton Hall, "Colour Vision and Colour Blindness," by Dr. Edridge Green, C.B.E. (Slides).

THE SHEFFIELD ASSOCIATION OF METALLURGISTS AND METALLURGICAL CHEMISTS.—Tuesday, October 4, at 7.30 p.m., at the Royal Victoria Hotel, Sheffield, "The Constitution of Chromium Steels," by Mr. T. F. Russell, Assoc.Met.

INSTITUTE OF TRANSPORT.—The programme of the Institute of Transport gives a list of eight meetings to be held in the forthcoming session. These commence with the presidential address by Sir Henry P. Maybury, on October 17, to be followed on November 14 with a paper by Mr. H. Kelway Bamber, on the "Possibility of Improving Train Loads." Subsequent papers cover transport law, commercial airways, railway problems in Australia and China, &c., the session closing with a paper by Mr. Roger T. Smith on "Improvements in Electric Traction." A syllabus has also been issued of lectures organised by the Institute for graduates and students to be delivered in the hall of the Royal Society of Arts. These also take place monthly, commencing on October 21, with a lecture on "Coastwise Water Transport," by Mr. M. Salt. The ordinary meetings of the Institution will take place as formerly, at the Institution of Civil Engineers, Great George-street.

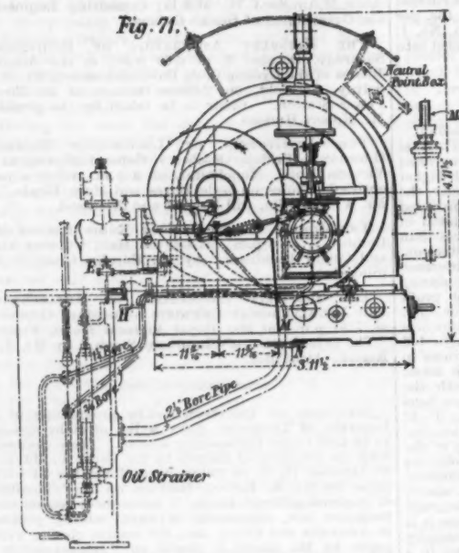
THE LATE MR. KENNETH RUSHTON.—We regret to have to announce that Mr. Kenneth Rushton, vice-president in charge of engineering, of the Baldwin Locomotive Works, died September 2, 1921, at the age of sixty years. Mr. Rushton was born in Philadelphia, Pa., served an apprenticeship as machinist under Hugo Bilgram, of Philadelphia, afterwards entering the Baldwin Locomotive Works, in April, 1881. Mr. Rushton's association with the Baldwin Locomotive Works continued from that date until the time of his death; first as a draughtsman, and later as designer, chief mechanical engineer, and, finally, as vice-president. He designed many appliances used in the construction of locomotives, and was closely associated with S. M. Vauclain in the development of the four-cylinder compound that bears the name of the latter. Mr. Rushton represented the Baldwin works in several important missions. In 1913 he went to Chili, and in 1918 to France, in connection with the design of railway transport for artillery. He was a member of the American Society of Mechanical Engineers, and served on the Locomotive Boiler Sub-Committee of the American Society of Mechanical Engineers' Boiler Code Committee. He was also a member of the American Society for Testing Materials.

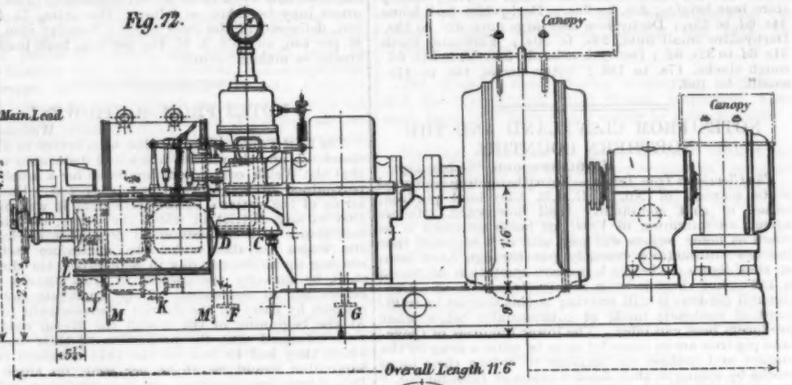
THE INSTITUTION OF GAS ENGINEERS.—The annual general meeting of the Institution of Gas Engineers, will be held at the Central Hall, Westminster, on Tuesday and Wednesday, October 11 and 12, commencing at 10 a.m. on each day. On both days there will be an afternoon meeting at 3 p.m., while there will be a reception on Tuesday evening at the Royal Institution of Painters in Water Colours, at 8.30 p.m., and visits to works, &c., of interest on Thursday, October 13. The Tuesday morning meeting will be opened by the president, and a congratulatory address will be presented to Mr. Samuel Glover. Subsequently the council's annual report will be presented, and the Fifth and Sixth Reports of the Gas Investigation Committee (respectively on Recording Gas Calorimeters and Blue Water Gas) will be discussed. Discussion will also take place of a report of the Refractory Materials Research Committee. In the afternoon a paper by Sir G. Beilby, on "Steaming in Vertical Gas Retorts," will be read and discussed, to be followed by one by Mr. G. M. Gill, on "Carbonisation in Horizontal Retorts," after which a report of the International Commission on the Illumination Conference at Paris, will be considered. The Wednesday session will commence with the business of the annual general meeting, to be followed by a paper by the Society of British Gas Industries on "Tar Distillation and Sulphate of Ammonia Manufacture," after which a report of the Institution Gas Research Fellowship will be taken, on "The Liberation of Nitrogen from Coal and Coke as Ammonia." On the afternoon of that day a report on the Life of Gas Meters will be considered, and also a paper by Mr. J. G. Taplay, on "The External Corrosion of Services and Mains." Details of the Visits may be obtained from the secretary.

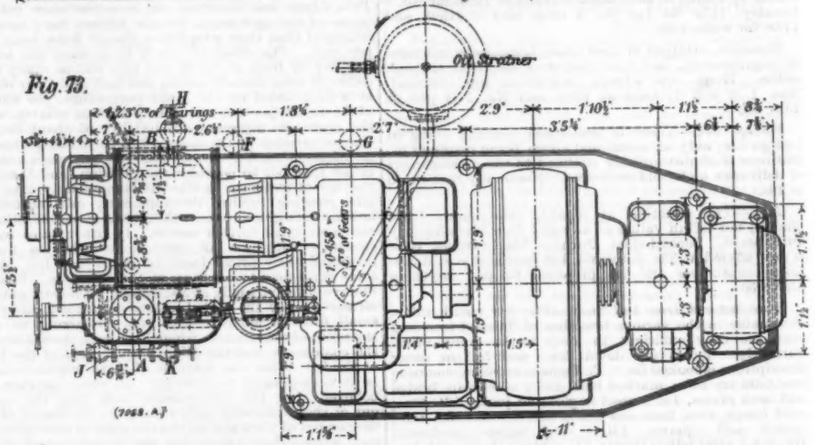
120-K.V.A. THREE-PHASE GEARED SHIP'S LIGHTING TURBO-ALTERNATOR SET.

CONSTRUCTED BY THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, ENGINEERS, MANCHESTER.

(*For Description, see Page* 470.)







SILICOTHERMY AND THERMISILID.

WHEN silicon is added to the metals of the iron group at suitable temperatures, silicides, compounds between the silicon and the metal, are formed, and this formation is accompanied by a generation of heat. The fact was known, but very little attention has been paid to it by the manufacturers of silicon alloys. With the ordinary processes in use the spontaneous rise of temperatures is indeed likely to be overlooked. When we melt iron and drop a little silicon into the fused metal, the relative mass of the silicon is too small to cause any striking evolution of heat in the already liquefied metal, in the excess of which the silicide dissolves. When more silicon is added, the heat of reaction is smaller, because the silicon does not react any longer with pure iron. Thus the gradual addition of the silicon will not lead to any great instantaneous heat evolution, though the final heat balance should not be affected by the time over which the reaction is spread. The phenomena are different when we heat the solid materials together. Then a reaction will suddenly set in at a certain temperature, with almost explosive violence if the materials are powdered, and the resulting product will be more homogeneous and may be both mechanically and chemically stronger. These are the leading features of a lecture on "Silicothermie" which Richard Walter, of Düsseldorf, delivered before the Gesellschaft für Metallkunde last winter (*Zeitschrift für Metallkunde*, 1921, pages 225 to 233). The term "silicothermie" was justly criticised by Guertler at that meeting. The term is coined after aluminothermy, a process in which a metallic oxide is reduced by powdered aluminium, the heat of the "thermit" reaction being sufficient to fuse the whole mass. There is no reduction of an iron oxide by silicon in the manufacture of Walter's "thermisilid," a new acid-resisting silicon-iron, which is made by the firms of Friedrich Krupp, of Essen, and the Maschinenfabrik Esslingen. But Walter considers his own, thermochemical method of preparing alloys of silicon with iron, and also other metals, in definite proportions, sufficiently distinct from the ordinary technical fusion processes to justify a special name. He did not give much practical information about the details of the operations and the treatment of the alloy adopted to secure a grainy structure; some additional information came out during the discussion.

When a piece of silicon and a piece of iron, not in actual contact with one another, are heated to about 1,200 deg. C. the vapours of silicon diffuse into the iron, and the two lumps unite in fusion. Walter seems to disintegrate his materials and slowly to heat them up to 1,200 deg. or 1,250 deg. C. When the temperature is then quickly raised a little, the reaction sets in, and the temperature may rise above 1,800 deg. though it should not actually go up so much. When the proportion of Si to Fe is 20 : 80, the silicide Fe_2Si is formed; when 67 : 33, the silicide Fe. S. The heat of the reaction is greatest with pure electrolytic iron; it diminishes as the carbon in the iron increases, and there is no noteworthy spontaneous generation of heat when cast-iron and silicon are heated together; the carbon of the iron thus plays an important part in these reactions as in others. Iron high in silicon is brittle. According to Walter an increase in the carbon per cent. tends to diminish the brittleness. Some silicon carbide is also formed then. Sometimes it is advisable to fuse the silicon or high-grade ferro-silicon used separately, before adding the whole to the fused iron. Attempts to prepare the alloy in electric furnaces have not been successful.

The microphotographs which Walter exhibited showed that some German foundry product—during the war the manufacture of acid-resisting alloys was taken up, over there as elsewhere, by incompetent people—was full of holes filled with segregated graphite; the alloy had been made in a cupola fed with coke, and an excess of carbon had been dissolved by the iron and rejected again. In some more recent German alloy the FeSi first formed had disintegrated into the more stable Fe_2Si. The instability of some English and American silicon-irons, pre-war specimens, Walter ascribed to the presence of both FeSi and a solution of silicon in carbon-iron, and further to the dendritic structure of the alloy. His own thermisilid showed light-coloured polygonal grains of Fe_2Si in a ground mass of a solution of silicon in carbon-iron. When the Fe_2Si appeared in distinct dendritic crystals, the mechanical strength was low, owing to internal strains; by different heat treatments the same material could be obtained either very hard or soft, but full of threads of fine scaly graphite, both the modifications being mechanically unsound.

Walter stated that his product was nearly of the strength of cast-iron, and that it resisted corrosion by acids remarkably well, though not corrosion by chlorine or by sea water. The shrinkage is said to be very low. The illustrations in the journal quoted of thermisilid articles—a boiler more than 2 m. in diameter of 3½ tons weight, digesters with elbows, retorts, pipes, valves, centrifugal pumps, &c.—did not mark any advance on the tantiron products which we described in our issue of August 9, 1918.

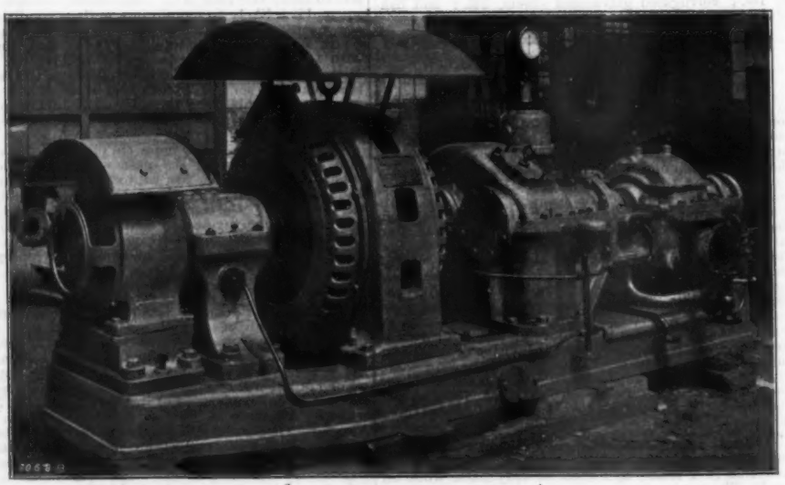


FIG. 74.

10-IN. CENTRE CHUCKING E A

CONSTRUCTED BY THE GISHOLT MACHI PANY,

(For Descr e Page 4

Fig. 5.

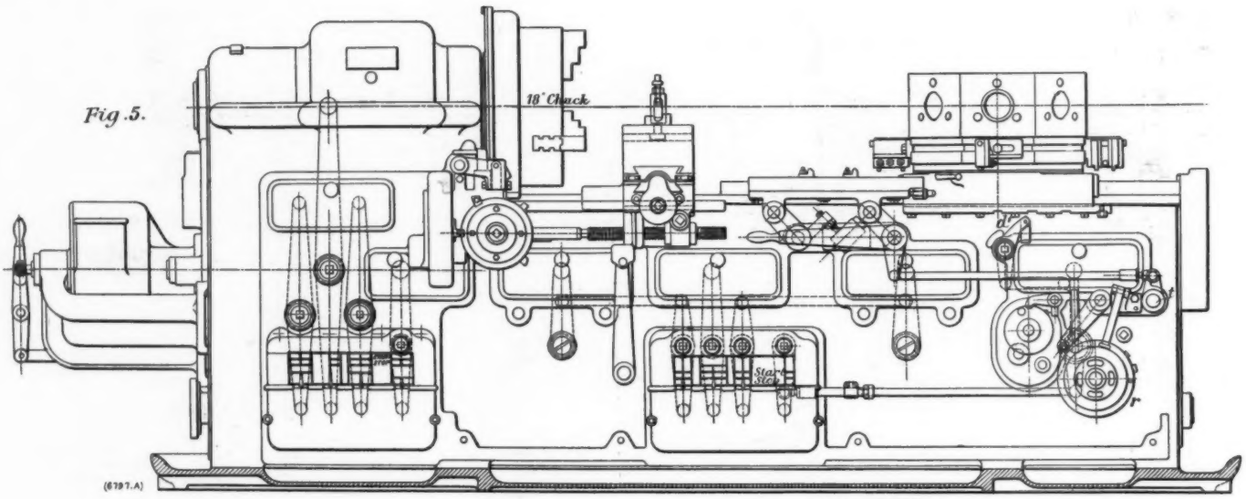


Fig. 6.

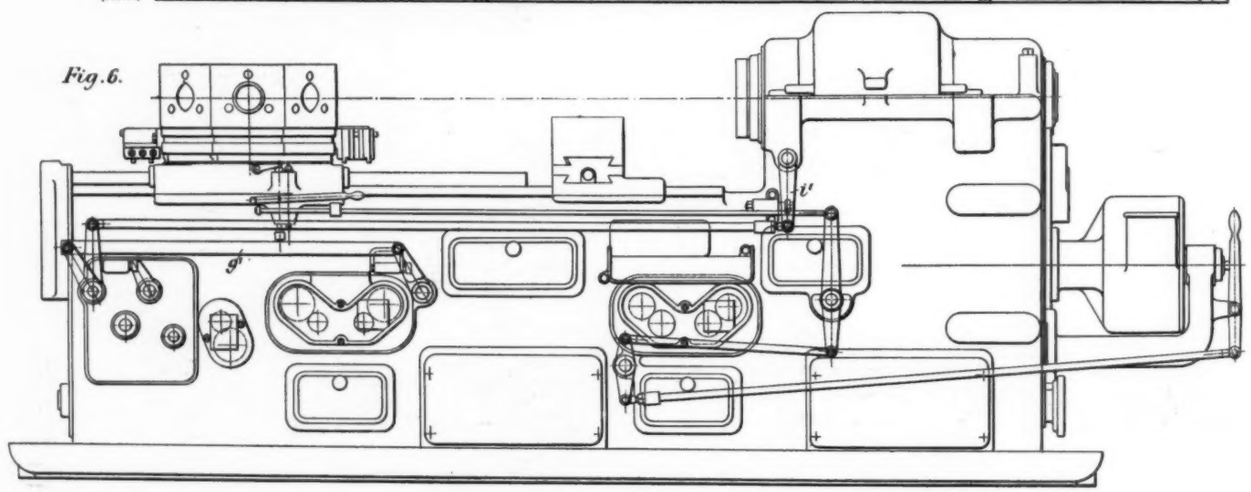


Fig. 7.

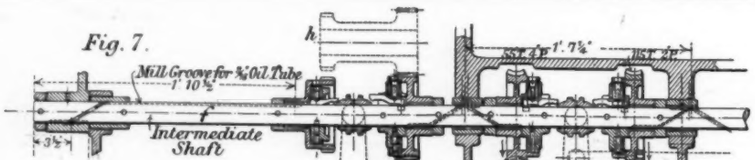


Fig. 9.

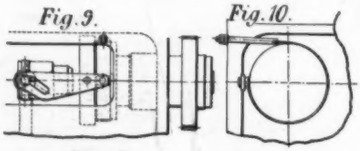


Fig. 10.

Fig. 8.

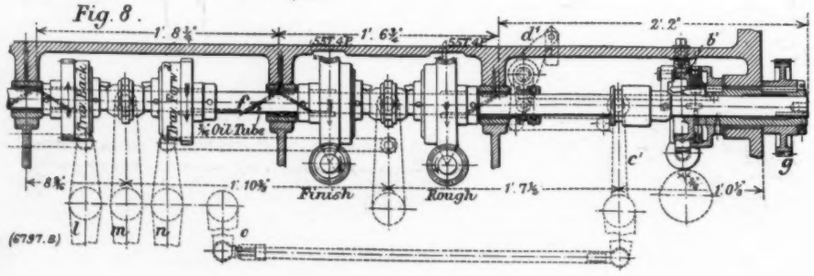


Fig. 17.

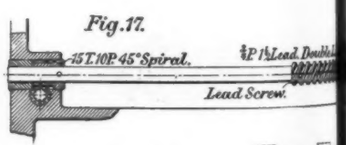


Fig. 18.

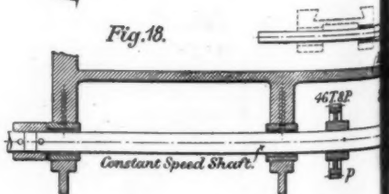


Fig. 19.

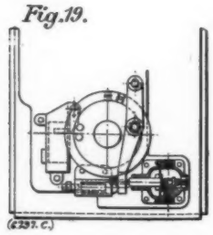
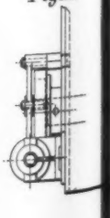


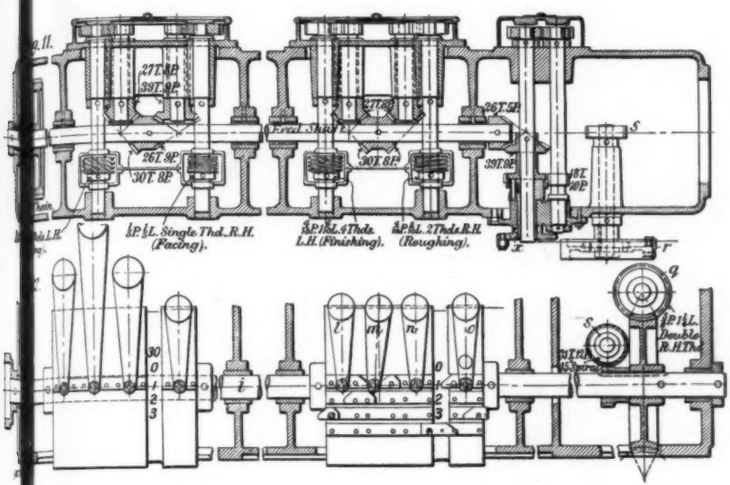
Fig. 11.

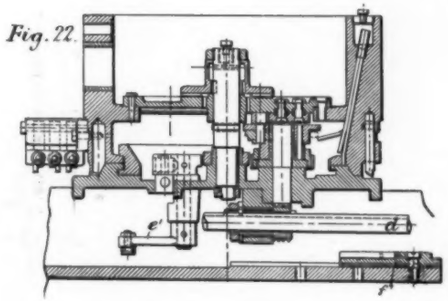


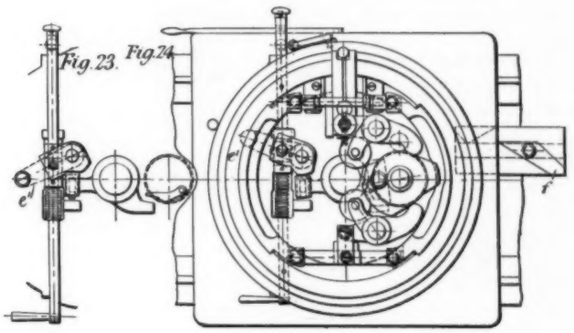
E AUTOMATIC TURRET LATHE.

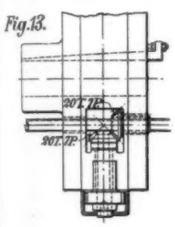
PANY, ENGINEERS, MADISON, WISCONSIN, U.S.A.

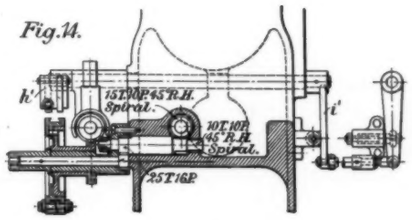
Page 463.)

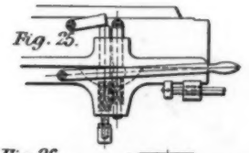


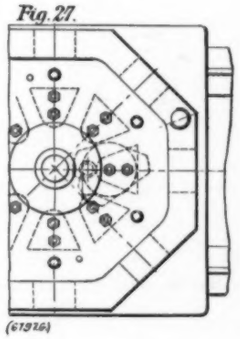


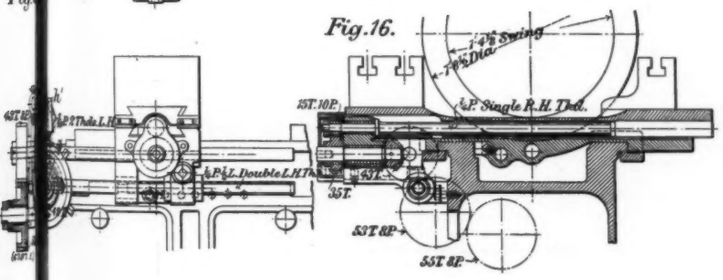


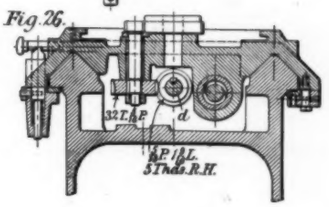


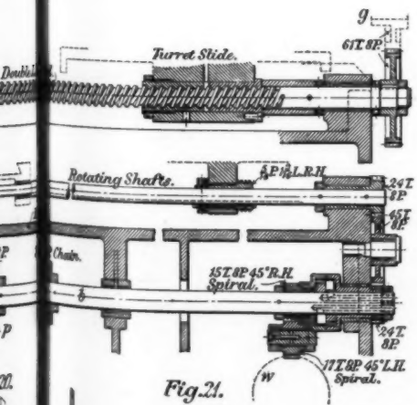


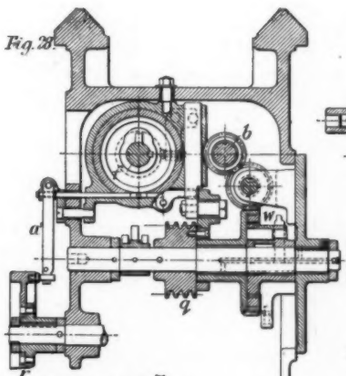


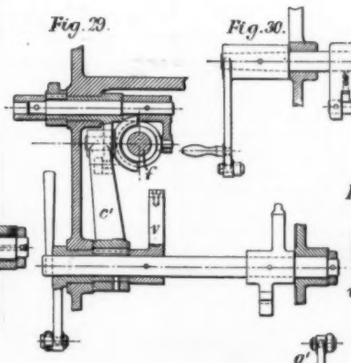


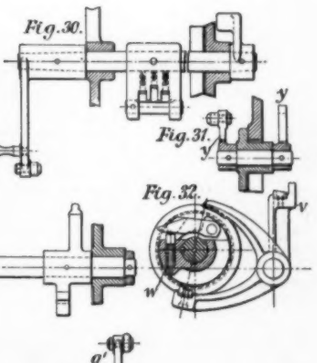


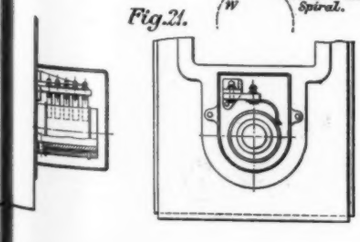


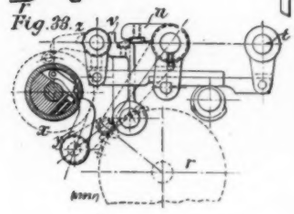


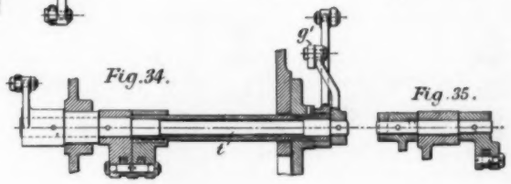












AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: E. F. Satchell, 58, Rue du Tabellion.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Ltd., 37, Queen Street East.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink, and Co., Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino. And any post office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Wm. Dawson and Sons (South Africa) Ltd., 20 and 31, Long Street, Capetown.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 453, Fourth Avenue. For Advertisements, J. S. Allan, 30, Church-street, New York.

ADVERTISEMENT RATES.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3 5 0
For Canada—	
Thin paper copies	£2 18 6
Thick paper copies	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick paper copies	£3 7 6

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

CONTENTS.

	PAGE
10-In. Automatic Turret Lathe (*Illus.*)	463
The British Association (*Ill.*)	467
The Shipping, Engineering and Machinery Exhibition at Olympia (*Illus.*)	470
Notes on New Books	474
The Temple Submarine Stud Driver	475
Industrial Notes	476
Notes from South Yorkshire	476
Notes from Cleveland and the Northern Counties	477
Notes from the North	477
Notes from the South-West	477
Notices of Meetings	477
Silicothermy and Thermisilid	478
The Use of Town's Gas in Industrial Works	479
Shorter Hours	480
Hydraulic Stowage in Mines	480
Notes	480
Agricultural Tractor Trials	481
The Institute of Metals	483
Literature	485
Books Received	485
"Stresses in Ships' Plating Due to Fluid Pressure"	486
Large Gas Engines	486
The Late Sir John Harold Heffernan	486
The Extrusion Defect (*Ill.*)	487
The Relation between Mechanical Properties and Micro-structure in Pure Rolled Zinc (*Illus.*)	489
The Use of the Sclerescope on Light Specimens of Metals (*Illus.*)	492
ENGINEERING Patent Record (*Illus.*)	494

With a Two-Page Plate of a 10-IN. CENTRE CHUCKING TYPE AUTOMATIC TURRET LATHE.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 477.

ENGINEERING.

FRIDAY, SEPTEMBER 30, 1921.

THE USE OF TOWN'S GAS IN INDUSTRIAL WORKS.

IN the advocacy of the use of oil for industrial purposes there is a danger of insufficient heed being paid to the fact that oil supplies, at the best, are limited, and that practically all have to be imported. The more general use of such a fuel, even if the best organisation possible ensures regularity of supply in normal times, tends decidedly to aggravate, instead of to relieve, our economic position, in these days when our imports are in any case far larger than they ought to be. The oil interests are naturally anxious to increase the volume of their business wherever there is the prospect of a good market, for which neither we nor anybody else will blame them, for they have a very useful commodity to dispose of; but, with the balance of trade sadly against us as a result of having to draw on other countries for foodstuffs and sundry other necessaries, it would seem to be most economical to reduce as much as possible our fuel imports, and to develop the use of home supplies, of which we are furnished with such ample native stores in the form of coal.

The improved and economical production and use of coal should, it would seem, in a country placed as we are, elicit far more interest and attention than is being devoted at the moment by the country generally to the use of oil. The latter is largely the result of a reaction following upon the unstable and uneconomical condition of the coal industry, though the fuel has inherent attractions of its own. Whatever these may be, or the advantage it possesses in tending to make us partly independent in times of labour crises, except in special cases, the purchase and use of oil cannot be regarded as the soundest policy for what must mainly remain, if we are to retain any position in the world at all, a coal country. Exceptional cases would, of course, embrace conditions under which greatly enhanced capacity may be for a time required, as occasionally occurs with boiler plant which, with oil fuel, can be forced to far greater output, and that more quickly, than is possible with coal. Special advantages also recommend it for use in warships and passenger liners, and so on. While recognising these it is impossible to overlook the fact that oil has traded a good deal on our national distress, in order to press, not without some degree of exaggeration, its claims as a remedy for our troubles. Rather than place reliance upon this outside support, it would be far more to our profit to try and improve matters so as to make possible cheaper coal and cheaper coal gas. Both of these would at the present time be of inestimable value in our industries, and especially in many of those which should properly contribute to our normal export trade, which is what we all desire to encourage.

As an industrial fuel in certain directions coal gas is fairly well established. In Sheffield, for instance, there are said to be over 2,000 gas furnaces ordinarily at work in the metal industries. It has often much to recommend it. Assuming for the moment that it is, to put it in the worst light, not an uneconomical method of using British thermal units, the use of gas supplied by an outside company relieves the works staff of all the worry of securing regular supplies of coal, of the trouble of unloading and otherwise handling this coal right to the furnace door, and of storing. Often in industrial centres space is too valuable inside works areas to be wasted on the storage of large quantities, and the irregularity of small consignments may give many an anxious moment to the works management. To be able to draw as desired on a large central station gives the factory using town's gas heating furnaces, advantages analogous to those secured in a machine workshop driven by electricity from a public supply. The latter plan is nowadays accepted as good practice, and the arguments advanced for it are familiar to all.

Clearly, in addition to the simplification of the fuel supply question, there are other points in favour of the method. The handling and disposal of clinker and ashes are obviated in the works, and a general freedom from dust and dirt is very noticeable where fires and ovens of this class are employed. There is an obvious saving in capital costs, and as considerable floor space is saved both in the sizes of the furnaces and in storage, the available room can be made more productive. On the latter factor gas has an immense advantage over coal, in the speed with which a furnace may be raised to working temperature, and the ease with which that temperature may be controlled. The first of these characteristics means that a furnace can, depending on the size, be prepared in a few minutes or hours, as compared with hours or even days for coal. This alone may frequently have a great bearing upon output. In the case of temperature control there is perhaps no other heating agent to compare with gas when used in a well arranged furnace, and the fact that the system is adopted in numberless processes where small departures from the desired temperature would ruin the product, is sufficient proof of the advantages it can offer in this direction. Where such features control, the choice of fuel gas can more than hold its own.

It may be argued that in some of the points we have referred to the advantages named are shared by oil. Quickness, for instance, in lighting up is also a recommendation for oil fuel, but while in cleanliness and ease of handling oil may approach—though it cannot equal—gas, as regards arranging for supplies and storage, it is a long way the more inferior fuel from the works management point of view. We are, of course, speaking of town's gas, supplied to works from an outside source, and not of producer gas, which still involves the planning of a regular fuel supply, though where the refuse of some subsidiary process inside the works is utilised in the producer, actual economy in the fuel will often override all other factors.

We may take it that, with modern appliances and with a reasonable price of coal, the case for town's gas has been amply proved for special work such as annealing and heat treatment. There is also a great deal of evidence to show that the direct saving in fuel is often substantial for bar heating, rivet heating, the heating of small billets and forgings, &c., quite apart from the practical works advantages we have discussed above; but the evidence in favour of its application to larger work is not so plentiful. It was with some feeling of disappointment at not finding more attention devoted to this aspect of the matter that we read Mr. G. Keillor's paper on "Gaseous Fuel in the Shipbuilding World," presented to the Annual Conference of the British Commercial Gas Association, held in Glasgow on Tuesday and Wednesday of this week. Mr. Keillor devoted a good deal of attention in this paper to annealing, heat treatment, case hardening, rivet heating and so on, practically all comparatively small work, but skimmed lightly over the question of larger jobs. It is true he spoke of gas heating for heavy forgings, having been proved to be cheaper by 51 per cent. than coal, and giving a 10 per cent. increase of output; also he spoke of the wonderful success following its introduction into American shipyards, and implied that there was no difficulty in producing large and at the same time economical furnaces up to 40 ft. long or so. From his opening remarks one might have been led to believe that the convincing evidence of large scale jobs would be quoted from other industries and from the shipbuilding industry in America, but in this respect the case has unfortunately not been very well presented, and, as we have said, the author no more than touched upon the handling of large scale work such as is frequently necessary in shipbuilding.

With regard to the smaller jobs, his data are interesting, and his points on the whole, fair. While contending that rivet heating by gas is now as practicable as with the ordinary coke fire, he quite naturally claims for gas fires the saving in cleaning up spilt coke and ash, about the work and particularly in ships' bottoms, the absence of falling

cinders and freedom from smoke, all valuable features in connection with work in confined and awkward spaces. While the gas rivet fire may have been reduced to practical and portable dimensions, it must perforce suffer slightly from the fact that it requires a piped supply of fuel. Where, however, pneumatic riveting is the practice this is no valid objection, as the rivet forge is practically never required to be in less accessible situations than the hammers served, and the latter are piped as a matter of course. It is possible with a reducing valve to use this pneumatic power line for the supply of air to the forges when only certain fittings and a gas line are required. This still involves two flexible connections to the forge, which can be obviated by employing the combined system of supplying gas and air ready mixed from a central plant.

How far the latter is desirable has yet, we believe, to be demonstrated. It involves the mixture in the pipes being explosive, a point not to be lost sight of in large works where the mains, if supplying a number of big heating furnaces, would be of considerable size. It also requires special gas and air compressors, and it is somewhat natural, on the whole, that the so-called air blast system should be preferred where frequently compressed air is already installed.

In marine engineering, as in other branches of the engineering industries, the advantages of gas for various jobs, including much awkward shrinkage work, have long been known. In some of these cases the special adaptability of this fuel to peculiar conditions, coupled with its cleanliness, practically cut out all competition, even if crude methods are employed, proving somewhat extravagant in fuel. In shipbuilding we believe that the displacement of the present fuels for furnace work will depend upon convincing the management of actual fuel economy to be derived from the use of gas. If works are satisfied that high-priced oil is superior to coal, it ought not to be difficult to prove the claims of gas supplied at a reasonable figure. Mr. Keillor states that gas furnaces having an efficiency of 41 per cent., compared with 18 per cent. of earlier patterns, are now available, so that it is evident, as is, indeed, well known, that great improvement has been brought about in design; and it should be borne in mind that even supposing some slight extra consumption should prove necessary in the furnace, the indirect savings and convenience place reasonably priced town's gas in quite a favourable position. It is practical facts on these points which the advocates of gas would do well to bring forward. Views of operations do not alone carry much weight, and a paper going fairly into the use of gas for the larger sizes of work is still wanted. We hope the subject may commend itself to one of the many able workers in the gas industry.

SHORTER HOURS.

Those who are interested in political economy in its application to some of the doctrines advocated on labour platforms should know that Mr. J. H. Thomas has had the courage to expose one fallacy which has deceived and still continues to deceive many working men. We refer to the argument which is often advanced in support of the claim for shorter hours: "If men employed in a particular industry are compelled to work short time, there will be more for others to do." Speaking at a private meeting of the National Union of Railwaymen, Mr. Thomas is reported to have said*: The cry that shorter hours finds work for somebody else is wrong. The idea that by reducing hours of labour you give work to other people is as great an economic fallacy as ever existed." He added: "The railways to-day are faced with a competition that is colossal." We fancy that many another Trade Union leader shares the view of Mr. Thomas; but how few of them there are who would venture to agree with him on a public platform. Those who have read George Borrow's "Lavengro" will remember the celebrated dictum of the Man in Black: "You may say in the dingle what you may not say in the public house!" Nor is it difficult to understand why the working man has been eager to adopt the theory which Mr. Thomas has denounced. It sounds so philanthropic! The worker is willing enough to work for short hours, and to salve his conscience by the reflection that he is benefiting his fellow men. Again it is not easy to expose the fallacy, and the explanation can only be understood by people who are acquainted with the principle that the limit to the employment of labour lies in the productive power of the agents employed in performing it, in other words, in the increasing cost of production. As Professor Cairnes wrote in 1874: "The work is there to do, but the efforts needed to accomplish it are greater than the product is thought to be worth. Here is the true and only limit to the employment of labour; and its removal or extension is to be sought, not in multiplying the obstacles that oppose the satisfaction of human desires, and so 'making work,' but in precisely the opposite direction—in the removal, as far as may be, of such obstacles, and in freely availing ourselves of all arts and contrivances by which human effort may be rendered productive of larger result. Increase the productive powers of industry, extend the knowledge of the industrial arts which support and comfort mankind, and there is little danger that labourers will ever fail of employment for want of work to do." It is significant that Mr. Thomas, after denouncing the theory above referred to, should have gone on to point out that railways are faced with colossal competition. There was no need for him to bring evidence in support of this proposition; its truth is patent to everyone who sees a motor lorry carrying goods, or a char-à-banc carrying passengers on a public highway. Whether this competition will, in the long run, be effective may be an open question, but railwaymen must needs take it into account when framing their demands for increased wages or shorter hours. We can only wish that labour leaders who have at heart the interests of men employed in other industries had at hand such tangible evidence of competition when seeking to inculcate the lesson that to "go slow" is bad policy from every point of view.

* *Morning Post*, August 26.

HYDRAULIC STOWAGE IN MINES.

In the recently-published report of the Committee on Spontaneous Combustion in Coal Mines, attention was drawn to the advantages of "hydraulic stowage," by means of which goaf areas can be so completely and thoroughly packed with incombustible material, as to preclude the possibility of gob fires. Some further particulars of this system are given in a paper by Professor G. Knox and Mr. J. Drummond Paton, which is published in the September issue of the Proceedings of the South Wales Institute of Engineers. According to the authors the first recorded instance of hydraulic packing was the accidental result of the flooding of a tributary of the Dee, near Hawarden. The flood washed such large quantities of sand into the workings of an adjacent mine as to cause their abandonment. When subsequently reopened, the sand was found to have been so solidly packed that it was possible to extract the coal left in the pillars.

In 1884, the method was used in Pennsylvania in order to check a gob fire, and it was subsequently adopted to facilitate the working of a seam 40 ft. to 60 ft. thick, at the Kohinoor Colliery, Shenadoah. Some years later, viz., in 1901, an extensive plant for hydraulic stowage was installed at the Myslowitz Mine in Upper Silesia, and proved so successful that the system was adopted at a number of other mines in Austria, Germany, Belgium and France. Hydraulic stowage has also been adopted at many of the mines in the Rand. In this country the method has hitherto found very few applications, but it has been adopted at two collieries in Scotland, and at the Crowgarth iron ore mine, whilst a fourth plant is now being installed in Lancashire.

On the Continent, on the other hand, some very elaborate and expensive plants have been devised and erected for the efficient application of the system. The packing material is crushed to cubes ranging in size from $\frac{3}{4}$ in. to $1\frac{1}{2}$ in. The crushed material mixed with the proper proportion of water is passed down a vertical pipe in the shaft. This pipe is fitted at intervals with truncated cones which collect the material as it falls, and direct it again to the centre of the pipe. As the sand is thus kept away from the walls of the pipe, the wear is confined to the renewable cones. In the case of the horizontal pipes through which the packing material is carried to the site where it is to be deposited, the wear is so serious that it has been found advisable to line the cast-iron with porcelain. Another plan is to make the pipes egg-shaped like a sewer, and to fit them at the bottom, with renewable linings. At the place of deposit, brattice screens are used, if necessary, to limit the spread of the packing. The water drains away, leaving behind it the filling, and after filtration is pumped to the surface again. As indicating the scale of operations the authors state that it is not uncommon to expend 1,000 h.p. in this work.

The main leading from the shaft to the place of deposit has in the case of some mines been as long as 9,000 m. At one plant a cavity equal to 2,000 tons has been stowed in 6 hours. It is not absolutely necessary to have a fall from the bottom of the down pipe to the place of deposit, as the water can be made to transport the packing material up a grade of as much as 50 m. on a road 1,000 metres long, but a larger quantity of water has to be expended.

In working thick seams the method generally adopted is to take out the coal in two or more layers and to follow up the excavation as closely as possible with the packing, hydraulically stowed. In the case of thin seams where coal-cutters are used, the method is stated to have special advantages. Another claim made is that hydraulic stowage makes it practicable to win the coal under towns, railways or other public works without disturbance of the surface. Thus it is stated that certain pits in the neighbourhood of Krupps works were about to be closed down, as owing to the valuable property at the surface, the miners were required to leave some 50 per cent. of the coal undisturbed so as to provide effective support of the surface. Permission was at length obtained to try whether hydraulic stowage might not make it possible to dispense with this requirement. The plan was accordingly sanctioned, tentatively. The experiment was made at first on a small scale, but subsequently, as the method proved effective, the owners were authorised to remove practically the whole of the coal. The proved advantages of the system were considered so great by the authorities, that special arrangements were made for the transport of waste suitable for packing at rates of the order of one-tenth of a penny per ton-mile.

NOTES.

The Cleveland Technical Institute.

A new institute on lines which are somewhat new to this country was opened on the 22nd, by Sir Charles Parsons. Sir Hugh Bell presided over the inauguration, while the new institute is largely the result of efforts of Dr. J. E. Stead and Mr. J. H. Harrison. For some time it has been felt that the Cleveland Institution of Engineers required adequate accommodation for its work, while a branch of the North-East Coast Institution of Engineers and Shipbuilders also needed some centre at Middlesbrough. It was decided wisely to make one headquarters the centre of these two bodies, the outcome being the new institute, the membership of which is to be confined to the two parent bodies, together with the members of other approved local technical societies. A strong council was formed and was able to secure as a building a Methodist church, with meeting and class rooms, in a very suitable situation in Middlesbrough. With considerable skill the building has been well adapted to its new purpose, and now furnishes two lecture halls, library, lounge and reading room and other accommodation. The institute is to be governed by a council chosen from representatives of the participating bodies, and representatives of other supporters, holding office for two years. In addition to the reading of papers and education of the technical staffs, &c., the effort is to be made to give instruction to the workmen, in the form of popular technical lectures in the winter months, some of which it is hoped will be given by artisans themselves. The Institute will publish a bulletin of technical information likely to be of service

to the local industries, including abstracts from the foreign technical press. A technical intelligence service has also been arranged so that members requiring information of a technical character may have the assistance of a central bureau of practised searchers. Sir Charles Parsons, in his opening speech, congratulated the members on having made for themselves a common home, a scheme which had much to commend it.

The Electrically-Propelled S.S. "San Benito."

An important development in marine work, as far as this country is concerned, has been made by the completion of the electrically-propelled S.S. San Benito, by Messrs. Workman, Clark and Co., Limited, of Belfast. As is well known, much has been done in the United States in the development and application of electric propulsion, particularly for warships, but so far little has been done by British builders, and our shipowners and engineers have been inclined still to refrain from coming to definite conclusions on the question of the electric ship. Practice and experience go much further than theory in a matter of this kind; much argument will be saved; and the S.S. San Benito will form a very valuable piece of evidence bearing very directly on the problem. The United Fruit Company, of Boston, U.S.A., for whom the boat has been constructed, have rendered considerable service by having her built in the British Isles, and the builders, Messrs. Workman, Clark, are to be congratulated on their association with a piece of pioneer work. The vessel is 340 ft. long and has a gross tonnage of 3,724. Her electrical propelling machinery consists of a B.T.H. Curtis turbo-alternator placed amidships and driving a three-phase synchronous motor placed aft. This plant and the necessary control gear was supplied by the British Thomson-Houston Company, of Rugby, who, as is well known, are associated with the General Electric Company of America, which has had a large experience in this class of work. The boat was constructed under the superintendence of Captain Young, resident inspector of the United Fruit Company. She will trade between the West Indies, Central America and the United States.

The Society of Technical Engineers.

A society which was formed some three years ago, but till the present has not claimed much public notice, has recently come forward with a programme which is a rather unusual one in these days. We refer to the Society of Technical Engineers, which is not in any sense a technical institution, but rather a trades union, yet differing in fundamentals from what is commonly now regarded as typical of such bodies. A long period of careful study has resulted in the objects of this society being formulated. After the manner of a trades union it proposes to use its influence in the interests of its members, and the profession, but qualified by the somewhat uncommon proviso that consideration will be given, in any action taken, to the probable effect on the firm concerned, and on the interests of the industry generally. Whatever the practical outcome of the society's activities, it is certainly refreshing to find that there is a group of workers sufficiently enlightened to recognise that there may be an economic limit to their demands. The most interesting point of the programme, however, defines the attitude of the society towards unions of manual workers. The society does not in any way intend to associate itself with the Labour movement, nor make common cause with the ordinary trades unions in action taken to alter the conditions of service, neither will it associate itself with the Trades Union Congress. On the other hand, it will endeavour to co-operate with both employers and employees with a view to securing the advancement of the engineering industries of the British Empire. It is hoped that by consultation and co-operation with the organised manual workers it will be possible to find the solution of some, at least, of many problems which are confronting our works in these days, and tending to make our production costs too high for us to secure markets. The policy as at present defined may appear to be somewhat nebulous, but at least is capable of being construed to indicate that the body will render active assistance in furthering the re-establishment of our industry, on a prosperous basis, by enhanced personal effort and the diffusion of goodwill among the parties concerned, in place of the too common spirit of antagonism. We may say that only men trained as technical engineers are eligible for membership. The headquarters of the society are at 102, Belgrave-road, London, S.W. 1. The future of the body will be followed with interest. It has chosen a rather difficult path for itself, where it would have been very easy to adopt a ready-made policy, and for the courage of this step we hope it will ultimately reap the reward of being able to contribute materially to the well-being of the industry, and through it, of the country.

The Co-operation of Employers and Workers.

After a successful run of three weeks, the Shipping, Machinery and Engineering Exhibition at Olympia was closed on Wednesday last, the eve of its closing being marked by a dinner presided over by Captain H. Riall Sankey, president of the Institution of Mechanical Engineers, and attended by a large number of well-known engineers and others. The purpose of the dinner was "to commemorate the successful co-operation of employers and workers as exemplified at the Exhibition." The speech of the evening was made by Mr. W. A. Appleton, the secretary of the General Federation of Trade Unions, who proposed the toast of "Success to the Engineering Industry." It was somewhat difficult, he said, to be optimistic at a time when 550,000 workpeople in the industry were out of employment, but despite our present troubles he was an optimist. During the war, in 1915, he had visited Sheffield—which at that time was somewhat of a storm centre—as a member of a small committee to investigate labour questions. In spite of their sense of grievance, the loyal and unselfish desire of the workmen to aid the country at a crisis had filled him with admiration, and, as the speaker very delicately hinted, it had compared very favourably with the attitude of certain employers. He could not believe that the character of British workmen had changed in the interval. The aspiration of the worker was to secure some voice in the control of the conditions of the industry at which he spends his life. All history showed that this could not be secured by forceful revolution. Neither the revolution of a logical nation like the French, nor that of an imaginative and experimental nation like the Russian, has given workers any control of industry. The German workmen, a steady and industrious race, had secured no control of their industries by revolution, and the result of the recent experiment of the impulsive Italians who seized the factories, would be fresh in the minds of all. Mr. Appleton wanted workmen to have the highest real wages and standard of living which could be obtained, but the size of the fund available for the payment of wages was determined entirely by the value of the production given in return. The price which a purchaser would pay for goods was outside our control. If the British price was too high he would do without the goods or get them elsewhere. Substantially lower prices could not be quoted while rates and taxes were so high, and he hoped the question of taxation would be seriously tackled. Mr. T. Chambers, of the National Sailors' and Firemen's Union, in replying to the toast of "Shipping and Commerce," proposed by Mr. W. Reavell, M.I.Mech.E., also made a good speech. He said that there was undoubtedly a large and growing section of workmen ready to extend co-operation with the employers in getting trade down to a satisfactory footing. The extremists were not many, but they were active and noisy, and under present conditions of industrial distress they got a hearing which they would not receive in normal times. It was easy for them to pour their poison into the ears of hungry and workless men, who did not know where the next meal for their wives and families was coming from.

AGRICULTURAL TRACTOR TRIALS.

The Shrawardine Trials, which terminated last Friday, have demonstrated at least one fact, namely, that nearly forty agricultural tractors, comprising machines of very widely different design and type, can work steadily for a week without one of them being put out of action through any mechanical defect. During the course of the trials we did not observe any instance of stoppage of work on account of breakdown of the tractor, and we gathered from inquiries that such troubles as did occur were few and trivial. The implements appeared to need more attention than the tractors, and there is still room for improvement in the former as regards ease and certainty of adjustment. One could not help being struck with the great difference in the quality of the work turned out by different outfits, especially as regards straightforward ploughing. Some of this, indeed most of it, was very good, but some was anything but creditable, the furrow slices not being turned over for yards together, and long streaks of green being visible in the finished work. It would not be fair to blame the tractor for leaving the field in such a state, and one hardly likes to put all the responsibility on the ploughmaker, because similar ploughs under other circumstances were perfectly satisfactory. Some of the stubble fields were in such excellent condition for working that good work could be made by almost any sort of plough whatever, but on more difficult land it seemed evident that the slower the speed of ploughing the better the work.

It must not be inferred from this that tractors should work at a slower speed than they do, for there is no apparent reason why, if the "tool" is suitable, land should not be satisfactorily "machined" at any speed that is practicable for a tractor to travel at, always supposing that the latter is sufficiently powerful. The work of ploughing really consists in three operations, cutting the land vertically by means of the coulter, cutting it horizontally at the required depth by means of the share, and turning over the "furrow slice" thus produced by means of the curved mould board or wrest. The furrow-slice must be completely turned over during the time in which the mould-board travels its own length. It is therefore reasonable to suppose that, for equal quality of work, the faster the plough is hauled the longer the mould-board should be, as otherwise increase of speed of ploughing will involve much more severe action on the soil. This consideration would hardly seem to be appreciated sufficiently by implement makers, but a comparison of the work done at Shrawardine appears to justify the view that a plough for use with a high speed tractor should have a greater length and pitch of mould-board than would be necessary for similar work done at a slower speed of travel.

As regards the tractors themselves, the diversity of the ideas of the makers, as to the most suitable type of spuds to make the driving wheels grip was very noticeable. We had occasion to comment on this point at some length in connection with our article on the tractor trials at Lincoln last year (see ENGINEERING, October 6, 1920, page 481). Some used isolated chisel-shaped points distributed round the circumference of the wheel rims, others had angle irons disposed diagonally, and either ending flush with the wheel sides or overhanging unsupported for several inches on the outside. One had angle irons, of which the angle was the working point, instead of one of the flanges. Indeed hardly two makers adopted the same practice as regards spuds. The three chain-track machines did not afford the same opportunity for variety, but even in these it was noticeable that the Cletrac relied on sharp transverse upturned edges of the track plates for grip, whereas the Blackstone and the Renault depended on the more or less blunt and obtuse corrugations of the plates themselves. The long diagonal spuds on some of the wheeled machines have the possible advantage that no spud leaves the ground until the next one takes up the work, but against this is the tendency of sticky soil to adhere to the intervening spaces on the wheel rim and to prevent the full depth of the spuds being effective. The chisel-pointed spuds would not penetrate much of the ground at Shrawardine, so that the driving wheels acted as starwheels running on their points, the wheel-rims never coming into contact with the ground at all. There was indeed room to get one's hand between the rim of the wheel and the subsoil when the wheel was running in the furrow. Driving

in this manner involves a more or less jerky mode of progression which does not appear beneficial.

Another point as regards spuds is the length of time required in many cases to fit or remove them. A tractor is a machine which may frequently have to travel alternatively on soft soil and on roads, as when hauling a load between the field and the farm. Some improvement on the tedious method of fixing or removing muddy spuds one by one would be an obvious benefit, and designers might with advantage look into the practicability of providing a system of spuds which could be withdrawn below the wheel surface altogether or caused to protrude to any extent which the nature of the land might render desirable. Some mechanism analogous to that of a feathering paddle-wheel might be applicable to the road wheels of tractors, the position of the king-pin being altered when an increase or decrease of spud-action was desired. We believe that the Bray traction engines used for hauling guns in the Crimean war had some spud regulating device, and the idea might well be re-investigated now that haulage on soft ground is a matter of such importance. The large collection of German military tractors, brought together at Aldershot last year by the efforts of Colonel Hutchinson, Chief Inspector of Mechanical Transport, and thrown open to the inspection of our manufacturers by the courtesy of the War Office, showed attempts to solve the spud problem which were in advance of anything to be seen at Shrawardine. We referred to this exhibition in our issue of November 5, 1920, and described some of the devices. There is little doubt that the Germans were conversant with our own early designs of mechanical spuds, and it behoves British manufacturers now to acquire a corresponding familiarity with later developments. When a Government Department makes a really intelligent effort to help British manufacturing industry, by providing facilities for examination of otherwise inaccessible designs, its enterprise should be encouraged by full use being made of the opportunity.

With regard to chain-track tractors, there is a general opinion that these will haul almost anything on almost any ground, however soft, and that they will do this without exerting any excessive pressure on the ground. It is the usual way to divide the total weight of the machine by the total area of the chain tracks in contact with the ground, and to regard the result as a measure of the pressure on the ground due to the passage of the machine. Such a computation would give, for the Renault caterpillar, to which we referred in our previous issue, a pressure of only about 667 lbs. per square foot. This may represent the actual pressure exerted on the ground when the tractor is at rest or is merely travelling over it by itself, but it certainly does not do so when the tractor is pulling hard. We watched the big Renault machine very carefully when engaged in breaking up an old ley with two three-furrow ploughs. The ground was covered with a fairly heavy growth of rye grass, together with some clover, and the field had been spread with farmyard manure previous to ploughing. The soil was hard, and when the tractor was taking the ploughs up an incline, it had just about as much as it could do. The chain track slipped on the grassy surface as the corrugations could not bite through effectively to the soil beneath, but the interesting thing was that the tractor, weighing 3¼ tons, showed a noticeable tendency to rise in front. The ends of the leaves of the front spring separated visibly, thus proving that there was almost no weight being taken by the front part of the tracks. The weight on the hind part of the tracks was therefore very greatly in excess of that computed in the ordinary way, and may well have been comparable with that due to an ordinary wheeled machine of equal power. The change in the weight distribution when the caterpillar is pulling, is, of course, due to the reaction of the driving torque on the rear axle, and this torque is in excess of that usual with wheeled machines on account of the low gear of the caterpillar. We believe that there have been instances of military "tanks" rearing up on their tails, due to nothing else but the reaction of the driving torque. We have not, at the time of writing, figures as to the acreage ploughed by the Renault wheeled tractor and the Renault caterpillar respectively, but the former certainly did a much greater amount of work per day. It will be remembered that in both cases the engines were similar and of equal power. The wheeled machine weighed 34 cwt. and ploughed three furrows, and the caterpillar weighed 65 cwt. and ploughed six furrows.

One of the functions of an agricultural tractor is to drive stationary farm machinery, such as threshing machines, baling presses, chaff-cutters, &c. On this account all tractors are fitted with belt pulleys, but the variety of ways in which these pulleys are disposed is enormous. Many makers appear to think it sufficient so long as there is a pulley somewhere, so they put one wherever they can find a convenient shaft for it, quite regardless of consideration for the man who has to use the machine. Sometimes the pulley is tucked away between the side of the road wheel and the body of the tractor so that the only possible run for the belt is forwards, and very close to the rim of the front wheel. An alternative is to have the pulley right at the nose of the machine, the shaft being parallel with the wheels. This allows a drive at right angles to the tractor on either side, which gives some choice to the operator as regards the position of the tractor relatively to the driven machine. But it should be remembered that the tractor ought to be readily manœuvred into the desired position for driving, and it must be capable of a fine adjustment to and from the driven machine so as to get the belt to the required tension. When the drive is crossways to the tractor, it is quite a business to get the position right, and one machine when getting ready for its dynamometer trials took so long to be manœuvred into position that many of the spectators grew weary and went away to look at other things. When finally a suitable drive was obtained, two men with crowbars had to hold the tractor against the sideways pull of the belt. Another tractor failed to get into proper driving position within the thirty minutes allowed for this operation, although two chances were given to it. The most convenient position for the pulley deserves much more attention than has been given to it. Quite the most sensible arrangement we noticed was in connection with the Blackstone caterpillar tractor. Here a cross shaft ran through the engine casing and carried a pulley at each end. These pulleys were at different

TABLE I.—*Particulars of Tractors (Duplicate Machines Omitted).*

Number.	Name.	Nationality.	No. of Cylinders.	Bore Inches.	Stroke Inches.	Revolutions per Minute.	H.P. on S.M.M.T. Rating.	Price £.
1	Austin ..	British	4	3¾	5	1,500	27·39	360
5	Blackstone	British	3	5	6½	750	23·8	475
6	Case ..	U.S.A.	4	3⅞	5	1,050	20·4	365
8	Case ..	U.S.A.	4	4½	6	900	28·4	550
10	Case ..	U.S.A.	4	5½	6½	850	45·0	1,000
11	Cletrac ..	U.S.A.	4	4	5½	1,000	22·8	475
13	Fiat ..	Italy	4	4·14	7·1	900	28·5	520
15	Fordson ..	U.S.A.	4	4	5	1,000	20·0	235
17	Glasgow ..	British	4	4¼	5½	1,150	27·0	450
18	Hart Parr ..	U.S.A.	2	6½	7	750	28·8	498
19	Hart Parr ..	U.S.A.	2	5½	6½	800	17·8	398
20	Int. Junior ..	U.S.A.	4	4½	5	1,000	23·4	350
22	Lauson ..	U.S.A.	4	4½	5½	1,200	37·84	475
23	Parrett ..	U.S.A.	4	4½	5½	1,000	24·3	475
24	Peterboro'	British	4	4½	5½	900	32·2	520
25	Renault (wheel)	France	4	3·7	6·5	1,100	24·5	500
26	Renault (track)	France	4	3·7	6·5	1,100	24·5	725
27	Samson ..	U.S.A.	4	4	5½	1,000	22·9	275
29	Saunderson	British	2	5½	8	750	25·57	450
30	Titan ..	U.S.A.	2	6½	8	500	21·9	390
32	Twin City ..	U.S.A.	4	4½	6	1,000	31·6	475
33	Wallis ..	British	4	4½	5½	850	25·0	450
35	Avance ..	Sweden	1	6·85	7·32	600	13·4	500
36	Fowler ..	British	4	3¾	5½	1,200	23·0	400
39	Service ..	British	1	3½	4½	1,200	4·3	165
40	Simar ..	Swiss	2	3·23	3·7	1,400	—	220

NOTE.—Machines 5, 11 and 26 are caterpillar tractors. Nos. 35 and 36 are self-contained ploughing units, though for the purposes of the trials the former pulled independent ploughs. Nos. 39 and 40 are small machines for market gardens, &c.

TABLE III.—*Results of Belt Test.*

No.	Tractor.	Brake Horse-Power at Belt Speed of 2,200 Ft. per Minute.	Maximum Brake Horse-Power.	Remarks.
1	Austin (paraffin)	23·25	23·75	—
3	Austin (petrol) ..	25·2	26·5	—
5	Blackstone ..	24·3	24·3	—
6	Case	10·5	14·5	—
8	Case	20·0	26·5	—
10	Case	—	—	Did not line up in time allowed
11	Cletrac	20·5	23·1	—
13	Fiat	26·2	27·5	—
15	Fordson ..	16·0	21·5	—
17	Glasgow ..	17·5	17·5	—
18	Hart Parr ..	28·75	30·0	—
19	Hart Parr ..	17·5	17·5	—
20	Inter. Junior ..	21·5	22·5	—
22	Lauson ..	28·0	28·0	—
23	Parrett	22·3	24·9	—
24	Peterboro' ..	24·0	25·0	—
25	Renault (wheel)	21·5	24·0	—
26	Renault (track)	18·0	19·2	—
27	Samson ..	15·5	15·5	—
29	Saunderson ..	22·0	23·5	—
30	Titan	27·0	27·0	—
32	Twin City ..	25·25	29·25	—
33	Wallis ..	25·0	29·5	—
35	Avance	11·5	11·5	—
36	Fowler	19·25	20·0	—
39	Service	—	—	Belt pulley too narrow for test
40	Simar	—	6·25	Could not attain speed of 2,200 ft. per minute

NOTE.—The tractors were allowed 30 minutes to line up for the dynamometer belt test. The average time taken was from 2 minutes to 10 minutes.

TABLE II.—*Weights and Pressures.*

No.	Tractor.	Driving Wheels.	Total.	Area.	Pressure.
		lb.	lb.	sq. in.	lb. per sq. in.
1	Austin	1,848	3,164	128	14·4
3	Austin	1,848	3,164	128	14·4
5	Blackstone ..	5,484	—	938	5·85
6	Case	2,699	4,098	115	23·5
8	Case	4,991	7,097	171	29·2
10	Case	7,008	9,800	240	29·5
11	Cletrac	3,631	3,631	800	4·54
13	Fiat	3,857	6,097	171	22·6
15	Fordson	1,900	2,932	154	12·3
17	Glasgow	1,620	4,034	245	6·7
18	Hart Parr ..	4,091	5,681	143	28·6
19	Hart Parr ..	2,874	4,005	135	21·3
20	Inter. Junior ..	2,592	4,064	125	20·7
22	Lauson	3,360	4,875	165	20·4
23	Parrett	3,645	5,095	154	23·7
24	Peterboro' ..	3,962	5,962	175	22·6
25	Renault (Wheel) ..	2,567	4,463	162	15·9
26	Renault (Track) ..	7,505	7,505	1,500	5·0
27	Samson	1,868	3,208	159	11·7
29	Saunderson ..	4,249	6,021	137	31·0
30	Titan	5,087	7,268	175	29·0
32	Twin City ..	3,582	5,364	168	21·4
33	Wallis	2,978	4,260	165	18·1
35	Avance	4,373	6,782	165	26·5
36	Fowler	4,620	4,762	117	39·5
39	Service	132	—	—	—
40	Simar	—	—	—	—

NOTE.—In the above table, machines numbered 5, 11 and 26 are of the caterpillar type. In the case of these machines the area over which the pressure is computed is the length of track (centre to centre of sprockets) multiplied by the double width of the track chain. In the case of wheeled machines the area is taken as half that of the projected area of contact when the wheels are sunk 1 in. in the soil, the assumption being that the hinder half of the driving wheels are not in contact with the soil. The weights given are those officially measured, the machines being in running order with fuel, spuds, tools, &c., included.

TABLE IV.—*Results of Draw-bar Tests.*

No.	Tractor.	Pull to Skid Wheels.	Sustained Pull.	Speed in Feet per Minute.	Draw-Bar H.P.
		lb.	lb.		
1	Austin (Paraffin)	2,000	1,820	215	11·4
3	Austin (Petrol) ..	1,920	1,700	206	10·6
5	Blackstone ..	4,060	3,470	125	13·2
6	Case	2,090	1,710	161	8·4
8	Case	3,660	2,680	167	13·6
10	Case	5,080	4,080	152	18·8
11	Cletrac	2,940	2,650	225	18·0
13	Fiat	3,500	3,000	168	15·3
15	Fordson	1,750	1,385	175	7·35
17	Glasgow	2,900	2,450	166	12·3
18	Hart-Parr ..	2,870	2,445	225	16·7
19	Hart-Parr ..	1,860	1,580	175	8·4
20	Inter. Junior ..	2,200	1,700	143	7·4
22	Lauson	3,160	2,400	141	10·3
23	Parrett	3,480	3,140	135	12·8
24	Peterboro' ..	3,950	3,300	157	15·7
25	Renault (Wheel) ..	2,400	2,040	150	9·3
26	Renault (Track) ..	4,840	3,620	130	14·3
27	Samson	1,820	1,500	130	5·9
29	Saunderson ..	3,080	1,930	138	8·1
30	Titan	3,430	2,760	156	13·1
32	Twin City ..	3,000	2,470	175	13·1
33	Wallis	2,750	2,560	181	14·0
35	Avance	2,700	2,450	86	6·4
36	Fowler	2,040	1,990	124	6·4
39	Service	480	410	60	0·75

NOTE.—In every case the draw-bar pull was limited by the adhesion obtained with the type of spuds or grips which were fitted to the wheels, and the nature of the ground which was hard and dry.

TABLE V.—RESULTS OF OBSERVED PLOUGHING TESTS.

No.	Tractor.	Maximum Pull.	Average Pull.	Depth.	Acres an hour.	Fuel used per acre.	Fuel.	Remarks.
						pints		
1	Austin	1,980	1,720	5½	0·49	24·0	Paraffin	—
3	Austin	2,440	1,920	5½	0·51	23·0	Petrol	—
5	Blackstone	1,200	1,070	7½	0·62	15·7	Paraffin	—
6	Case	2,060	1,840	5½	0·46	18·0	Paraffin	—
8	Case	1,780	1,370	7½	0·82	19·8	Paraffin	—
10	Case	3,240	2,485	6	1·11	23·6	Paraffin	See Note 1.
11	Cletrac	1,900	1,780	5½	0·59	26·5	Paraffin	—
13	Fiat	2,500	1,650	7	0·69	15·3	Paraffin	—
15	Fordson	1,320	1,230	5½	0·58	23·5	Paraffin	—
17	Glasgow	1,870	1,630	6	0·54	18·8	Paraffin	See Note 2.
18	Hart Parr	2,590	2,240	7½	0·81	33·0	Paraffin	—
19	Hart Parr	1,190	910	7	0·45	30·2	Paraffin	See Note 2.
20	Inter. Junior	2,000	1,320	5½	0·53	24·6	Paraffin	—
22	Lauson	1,600	1,210	5½	0·74	25·7	Petrol	—
23	Parrett	1,880	1,370	7	0·62	17·8	Paraffin	—
24	Peterboro'	2,680	1,665	7	0·77	24·5	Paraffin	—
25	Renault (wheel)	1,460	1,010	7½	0·79	18·0	Petrol	—
26	Renault (track)	3,420	2,740	5	0·64	17·6	Petrol	See Note 1.
27	Samson	1,488	1,072	5½	0·42	24·4	Paraffin	—
29	Saunderson	1,500	1,030	7½	0·67	20·6	Paraffin	—
30	Titan	1,700	1,440	6½	0·68	25·5	Paraffin	—
32	Twin City	1,645	1,540	5½	0·71	27·0	Paraffin	—
33	Wallis	1,800	1,200	6½	0·78	19·0	Paraffin	—
35	Avance	—	—	6½	0·37	26·2	Crude oil	See Note 3.
36	Fowler	—	—	6	0·36	45·3	Petrol	See Note 4.
39	Service	—	—	6	0·12	12·9	Petrol	See Note 5.
40	Simar	—	—	4	0·19	25·6	Petrol	See Note 5.

NOTES.

1. These tractors hauled two 3-furrow ploughs.
2. These tractors had plots of awkward shape which caused loss at headlands.
3. This tractor, although designed as a self-contained motor plough, hauled a separate implement.
4. This machine is a self-contained motor plough.
5. These machines are garden cultivators, with walking operators.
6. Machines No. 5, 11 and 26 are caterpillar machines.

NOTE.—It would be misleading to draw any conclusions from the rate of fuel consumed per acre as given in the above table (as the nature of the ground ploughed was so variable). Direct comparisons can only be made on the basis of draw bar horse-power, and this comparison will be made in the final report.

sizes, thus giving two speeds of driving, and the drive from each could be equally well taken, either forward, backward or upwards, as nothing came in the way of the belt. Such convenience could perhaps hardly be obtained in the case of a wheeled tractor, but it is the ideal to be aimed at.

The tractors which showed most deviation from the generally-accepted lines of design were the Glasgow, with its three equal-sized ground wheels all power-driven, the Avance with its single-cylinder two-cycle hot-bulb engine, and the Simar, which is, properly speaking, not a tractor at all, but a mechanically-propelled machine which cultivates the ground by means of a revolving drum fitted with springy, hooked tines. It will reduce hard ground to a fine tilth for a depth of 8 in. or so in one operation, thus combining the results usually only obtained by the three processes of ploughing, cultivating and harrowing. We shall illustrate this machine shortly, and will therefore defer a full description of it until then. The Avance tractor had a certain crudity of design, and vibrated violently on its springs when undergoing the test for belt horse-power, an effect due no doubt to the inevitable unbalanced forces of a single cylinder engine. The remarkable adhesive and hill-climbing characteristics of the Glasgow tractor were shown at the Lincoln trials last year by the ascent of some rifle butts. The nature of the drive of this tractor causes no unbalanced torque, and therefore deprives the machine of any tendency to rear or to reduce its wheel pressure when pulling hard.

As in our report of previous trials we have illustrated most of the types of machines competing at Shrawardine, we need not illustrate them again on this occasion, but we give, in the accompanying tables some of their leading particulars, together with such of the results of the Shrawardine trials as are now available.

THE INSTITUTE OF METALS.

(*Concluded from page* 449.)

ON the members of the Institute of Metals reassembling on the morning of Thursday, the 22nd inst., at the Municipal Technical School, Birmingham, the first paper taken was one dealing with the extrusion defect, by Mr. R. Genders. We reproduce this on page 487 of this issue.

THE EXTRUSION DEFECT.

The discussion was opened by Mr. Redding, who emphasised the importance of the extrusion defect, which in the case of fuses made from an extruded bar might lead to the bursting of a gun and, in the Navy, to the loss of a ship. The proportion of failures through this defect increased during the war, owing to the increase in the proportion of extruded to rolled bars, and to the increase in the size of the bars which were obtained by extrusion. The speed with which extrusion was carried out was also a cause for the increase in failures he referred to. He (the speaker) had tried to remedy the defect in the year 1917, and carried out a series of experiments with wax cylinders, the skin of which was dyed red. He showed on the screen a series of lantern slides illustrating his experiments and the way in which the flow took place. The matter, the speaker added, should be taken further than the laboratory stage and a remedy found in actual practice, makers of extruded bars giving an assurance that the defect had been eliminated, otherwise engineers would decline to take extruded bars and use rolled bars exclusively.

Dr. Rosenhain said that the subject had actively occupied one section of his laboratory for the last five or six years. Some alloys were not readily worked until after extrusion. He (the speaker) had come across the coring defect and had tried to discover its cause and a remedy for it. The previous speaker had experimented with a plastic material, and he (Dr. Rosenhain) had made his experiments with plasticine of various colours, but of an equal degree of consistency throughout. Alternate layers were light and dark plasticine. Such laboratory experiments, however, could not be regarded as representing actual manufacture with metals, in which the temperature and other questions came in. He agreed with the author generally, but did not believe the defect was so much due to the action of the skin of the billet. The ram did not fit the container accurately; there was some clearance, and there was left in the container a shell. The oxidised back of the billet flowed down and led to the defect. He (Dr. Rosenhain) had placed between the ram and the billet a plate which gripped the back end of the billet and prevented the back surface from flowing in at all. He believed that an important cause for the occurrence was defects in the original ingot. He recommended the placing of the feeding end of the ingot towards the die. The author had suggested pushing the die in the metal. That was an excellent method, but it had its inconveniences, and it would be difficult to find a ram which would stand up to its work. If the inconveniences could be overcome there was a future for the method.

Mr. F. S. Tritton here showed a number of lantern slides illustrating the experiments made at the National Physical Laboratory with plasticine, and Dr. F. Johnson announced that Mr. Redding's wax specimens were on view in the Library of the Technical School.

Mr. H. Moore agreed entirely with the author, whose experiments had been made, not with wax or plasticine, but with 60 : 40 brass. Dr. Rosenhain had suggested defects in the ingots, but large discards were made from these and every possible measure was taken to have a perfectly sound metal to start with, placed both with the feeding end downwards and upwards, and in every case the defect occurred in the last 30 per cent. extruded. In 1914–15 they attributed the extrusion defect to the cavity in the ingots, but by studying the matter they had acquired the conviction that ingot defects had nothing whatever to do with it. If the ingot were a defective one the bar extruded from it would, of course, also be a defective bar. The pressure when extrusion was through the hollow ram was less than when using a solid ram and much less work was required. One object of the paper was to elicit information from the makers of extruded bars, and the meeting would very much like them to come forward and place their experience on record. The extrusion defect was still going on, although at the present time most of the extruded rod made was through a multiple die, and the defect was not serious to the same degree as occurred when a large rod was made. In this the skin appeared as a central defect in the rod.

Mr. Genders, in the course of his reply, said he was sorry no manufacturer had come forward, and he felt that the matter had therefore been dealt with in a rather one-sided manner. The war had put an end to the period of secrecy, for a time only, since secrecy was being observed again. He appreciated the seriousness of Mr. Redding's remarks. The speed of extrusion could not be called in question for the proportion of defective rod. A larger section would account for it, and in this connection he (the author) had said it would appear that the defect was present in the rear portion of all rod centrally extruded by the usual method, but in rod of smaller diameter the foreign matter might be distributed over such a great length as to render it discontinuous and invisible in the fracture. In small rod, therefore, the defect might exist and yet not be seen. With regard to the dirtiness of the central core formed, this sometimes was not very dirty, as was evidenced by his (the author's) view, Fig. 4, showing a loose core in a fuze. Mr. Tritton's slides illustrating experiments with plasticine hardly represented the flow as it was experienced with brass. His (the author's) Fig. 5 showed the formation of the defect with brass, and this was comparable to actual manufacture on a large scale, whilst in Fig. 11 foreign matter from the skin was absent owing to clearance of the ram in the receiver, but the mode of flow was always the same. He (the author) did not think the roughened end of the ram could have much effect, since he had found the back portion of the billet was practically dead metal, it kept on feeding in the funnel-shaped flow to form the defect. A rough end could only have an effect near the edge. Any remedy which did not alter the mode of flow would not do much to reduce the extrusion defect to any appreciable extent. Experiments on a large manufacturing scale would have to be carried out, but these were, unfortunately, rather costly.

The President expressed his regret that no manufacturer had taken part in the discussion; they ought, he thought, to have done so; it was a duty they owed the Institute. The author's work was a most interesting one, and one which would be useful to them, the actual manufacturers.

THE USE OF THE SCLEROSCOPE ON LIGHT SPECIMENS OF METALS.

The second paper taken at the meeting on Thursday was the one having the above title, by Mr. F. S. Tritton, who read it in abstract. This paper is reproduced *in extenso* on page 492 of this issue.

Sir Thomas K. Rose, who opened the discussion, said the scleroscope was a very useful instrument, and all work which tended to increase still further its usefulness was always welcome. Rough-and-ready means were followed with it in the shops after rolling and annealing, and precise figures were not considered of so very great importance as the

comparative figures it gave. Notwithstanding this, all methods, such as the author's, were to the good. Here the speaker explained difficulties which he had some years ago, the packing he used under the specimens, and the longer lever and greater pressure he resorted to.

Captain Hartland asked whether the grinding down of a specimen before testing for hardness might not have an annealing effect. Even the vibration set up by the grinding might cause a modification in the crystallisation having a similar effect, yielding a softer specimen. Apparently, that effect did not occur. In supporting the specimen in a vice, testing it across, a higher value was found at the sides than in the centre, also when supported in copper grips the value was higher than when steel grips were used. A paradoxical result seemed to be that higher figures were given when the specimen was supported on lead than when it was supported on hardened steel. More data would be welcome on the above points.

Dr. Hatfield expressed the opinion that the use of the scleroscope should be largely restricted to experiments where the Brinell test did not apply. In hardened steel and cold-worked material, the scleroscope was of great importance. The author's interposition of thin films would facilitate the hardness determinations. The author had stated that his experiments showed that hardness tests on under-weight samples, *i.e.*, samples so light that their inertia is insufficient to resist properly the kinetic force of the falling hammer, carried out in the usual ways recommended, did not give results with the accuracy of which the instrument was capable, adding that caution should be used in placing reliance on such results, and he (the speaker) emphasised these remarks of the author. The scleroscope values given in most papers presented to the Institute were generally unreliable. In the paper by Messrs. Alkins and Cartwright, read on the preceding day, for example, there was the anomaly that whilst the scleroscope hardness dropped, the tensile test figure went up.

Mr. H. L. Heathcote said that in the Rudge-Whitworth laboratory scleroscope readings varied sometimes by 100 per cent. in the case of steel balls of the same hardness; the scleroscope figure varied greatly with the diameter of the ball. In common with many, he had devised a simple means of determining the hardness of small pieces; his solution was to modify the Brinell device using an impact automatic centre punch. He removed the hardened point and replaced it by a ball holder. A variation of this had the shape of ordinary pliers. These appliances have been described in our columns.*

Dr. Gwyer could not recommend the use of pitch since the advantage of the scleroscope was the speed with which the hardness test could be carried out. The scleroscope was much the handiest instrument for testing the temper of sheets, but in the case of these the thickness of the sheets came in. He also had higher rebounds with lead supports. His experience with scleroscopes showed that no two gave the same readings; new hammers differed in weight by 10 per cent., and readings by 25 per cent.

The Relation between Mechanical Properties and Microstructure in Pure Rolled Zinc.

The third paper was the one having the title we give above; it was by Mr. D. H. Ingall, who read it in abstract. It will be found reproduced in abstract on page 489 of this issue.

The discussion was opened by Professor Turner, who said that the subject of working zinc in this country was now of considerable importance. We did not want to buy finished zinc, and he was glad our manufacture of finished zinc was being developed. The question had been once raised as to whether pure spelter could be rolled, the idea being that it was necessary for it to contain lead to roll it, and lead was added. It was now known that pure spelter could be rolled with excellent results. The author had described all the reagents he used for etching. He used dilute reagents and found that they gave much better results, and his (the speaker's) ideal was to use a reagent which took about 1 minute to act; as in photography he objected to a developer which was too rapid. The paper was a useful and well-arranged one; he congratulated the author upon it, and also upon his recent nomination as principal of the Technical College, Wednesbury. He wished him success in his new work.

Mr. Thornwell, who showed a number of slides, said the author's figures did not directly compare with his own, since the test pieces were different. Zinc was apparently so erratic in its behaviour and so much influenced by small variations in experimental conditions, that with our present knowledge he hesitated to make even wide generalisations. If the author could correlate ductility with microstructure and chemical composition he would render a great service to the zinc roller.

Mr. H. M. Ridge found the author's metal to contain 99·954 per cent. of zinc, and his impurity was mainly copper; his iron content was the usual one, but the copper content 0·033 per cent. was unusual. His title spoke of "pure rolled zinc," whilst his material was not pure. In regard to the addition of lead for rolling, if the zinc were high in iron it could not be rolled satisfactorily, and therefore lead was added to it to facilitate rolling, lead correcting the presence of more iron than was usual.

Mr. J. S. G. Primrose desired to call the author's attention to the name of the ferruginous zinc referred to in his (the speaker's) 1909 paper mentioned by the author. To zinc users and makers, the term "hard spelter" was quite definite and meant the bottom layer of the material formed in galvanizing tanks. This had to be periodically withdrawn and cast into ingots, these being subsequently sent to refiners to recover the zinc. The photo-micrographs reproduced in 1909 were intended to show the formation and distribution of the compound $Fe_{10}Zn$ in the eutectic ground mass. The etching was done either in hydrochloric or nitric acid in alcoholic solution immaterially. He (the speaker) then referred the author to very interesting work on zinc and the variation of its mechanical properties after rolling and annealing at various temperatures done some years ago by Wust and F. Robin. As to hardness tests, he recommended the author to consider a correction for the light loads he used and also the use of a sensitive depth indicator to determine the area instead of using the oval imprint.

Mr. Ingall agreed with Professor Turner that it was better to etch slowly than by a quick "flash" when there could be no control of the degree of etching. By working slowly etching could be stopped at will. His analysis had been made in the usual way, and, he confessed, he had some doubt as to the use of the word "pure," but expressed the hope that his work would be found useful from a general commercial point of view.

The Constitution and Age-hardening of the Alloys of Aluminium with Magnesium and Silicon.

The fourth paper taken was the one having the above title, by Dr. D. Hanson and Miss M. Gayler. It was read in abstract by the latter. This paper gave the constitution of the alloys used and stated that those of this system after quenching from high temperatures were relatively soft, but gradually became harder, the age-hardening ceasing after a few days. The age-hardening of a series of alloys containing increasing amounts of Mg_2Si rose progressively until the limit of the solubility of Mg_2Si in aluminium at the quenching temperature was reached, beyond which the total increase in hardness remained constant. Hence the increase in hardness produced during the ageing was roughly proportional to the amount of Mg_2Si retained in solution by quenching. Confirmation of this view was also obtained from experiments with alloys of aluminium and Mg_2Si with magnesium and silicon. We hope to publish this paper later.

Dr. Desch found the paper a model one on the ternary system, and expressed his pleasure at seeing the micro-sections representing what they intended to represent. The magnesium silicide compound appeared to him an unstable system. He also referred to the difference between original duralumin and the remelted product; the silicon content was larger in the latter than in the original product.

Mr. H. B. Weeks said that as the reputed English father of duralumin it might be fitting that he should make a few remarks on the subject. In the first place he would like to congratulate the authors upon having carried out what he considered a most important research, the results of which explained the peculiar property of age-hardening by annealing at ordinary temperatures, after quenching from suitable heat treatment. Wilson, who is credited with having made the discovery, as far as he was aware, was unacquainted with the formation of the compound which conferred the age-hardening property. He had looked up his notes and correspondence with Wilson on the subject and found that he stated that all aluminium contained iron and silicon as impurities and the maximum amount of the latter that should be present for the manufacture of duralumin was 0·7 per cent. Wilson stated that the presence of magnesium was essential, although he, the speaker, did not think that he even suspected that it was a combination of the latter metal with one of the self-contained impurities that was responsible for the very remarkable results obtained. He added both copper and manganese in order to increase the initial hardness of the alloy and left out the manganese altogether for the softest varieties for use in cases where much "work" was required to be put upon the material or greater durability needed.

To sum up the matter, there was an alloy possessing certain unique properties which rendered it capable of use where great strength and lightness were required, and which, as far as was known, was not adversely affected by age, as was the case with most other high aluminium alloys, which degenerated by intercrystalline brittleness in time. The alloy had, moreover, gained an amount of notoriety on account of its successful use for aircraft and airships both in this country and Germany, and the discovery of the cause of its age-hardening properties he regarded as a most important piece of work that was likely to have far-reaching effects. We knew that we were on the verge of wonderful discoveries relating to the sciences of chemistry and physics which might modify all our present ideas profoundly, and the results of the research carried out by the authors, he thought, would be epoch-making even if only by way of suggestion regarding the possible application of correct heat treatment upon other, and possibly better, known alloys.

Mr. H. Moore agreed with Dr. Desch and, referring to early work at Woolwich with light aluminium alloys, found that age-hardening occurred very rapidly. He did not find a great amount of age-hardening in binary alloys, but it was very rapid and intense in ternary alloys of suitable composition. A question arose as to whether it was due to magnesium silicide.

Dr. Hanson, in the course of his reply, said the magnesium silicide compound was very stable. It had a distinct appearance in the micrograph. Magnesium formed various compounds and seemed to reduce silicon before any other. It was interesting to hear Mr. Weeks' reference to the introduction of duralumin. Other alloys of aluminium did show age-hardening, and the authors did not want to suggest that magnesium silicide was the only compound to produce it; their experiments with copper-aluminium alloys confirmed that, but they found the effect of other compounds less than that of magnesium silicide.

The Electrolytic Etching of Metals.

The last paper taken at the meeting on Thursday, the 22nd inst., was that on "The Electrolytic Etching of Metals," by Mr. F. Adcock, who read it in abstract. In this, the author stated that a solution of citric acid as an electrolyte in the etching bath gave good results with cupro-nickel 80:20 and other metals. Another electrolyte made by dissolving molybdic acid in excess of ammonia solution gave somewhat similar results. By using such reagents as hydrofluoric acid, chromic acid, and bromine water, both the cores, or dendrites, and the crystal grain boundaries of cast cupro-nickel were disclosed simultaneously.

Dr. Desch said the etching up of the grain-boundaries and the cores simultaneously was an important point. Referring to the author's Fig. 17, a micrograph showing a double grain boundary in gold, he said the structure was a peculiar one,

* See ENGINEERING, vol. cxi, page 487.

which was still more clear in the original photograph. The process was liable to be of great service.

Mr. J. S. G. Primrose said if the author could show how a works could use the process easily it would be greatly appreciated.

The last paper on the list, "A Note on the Magnesium Alloy 'Electron,'" by Mr. S. Beckinsale, was taken as read. The Chairman thanked, on behalf of the meeting, all the authors for their contributions, which, he added, were all of exceptional interest, and showed a growing tendency to connect theory with actual works practice. Votes of thanks to the Lord Mayor, the University, the firms visited, the Municipal Technical School and the Local Reception Committee terminated the proceedings.

LITERATURE.

Report on the Materials of Construction used in Aircraft and Aircraft Engines. By Lieutenant-Colonel C. F. JENKIN, C.B.E., R.A.F., M.Inst.C.E. Published by His Majesty's Stationery Office, Imperial House, Kingsway, W.C. 2. [Price 21*s.* net.]

IT is doubtful if there has been, during the last century of engineering progress, any important advance which has not depended to a certain extent, if not wholly, upon a contemporaneous or antecedent development in materials. An examination of James Watt's letters throws much light upon the difficulty he had in finding suitable packing materials for the pistons and other parts of his engines, and to-day it probably can be said with assurance and truth that the aeroplane engine, with its small volume and weight per unit power, would have been impossible if it had not been for the metallurgical progress of the last twenty-five years, and the more complete understanding of the fundamental properties of materials, which the researches of modern times have made possible. Further, it is doubtful if there can be any very great progress in the future, in the efficiency and power per unit volume of the engine, unless either new materials are discovered, or methods of using the present known materials more efficiently, can be made possible. Experimentalists are looking to the possibility in the future of using the regenerative principle in connection with internal-combustion, so that the heat of the exhaust gases can be in some way utilised to heat the incoming charge. If this can be done increased efficiency will result, but the laws of thermo-dynamics demand that the temperature range of the engine shall be thus increased and such experiments that have, up to the present, been carried out indicate that the real difficulty probably lies in the finding of materials that will effectively withstand the very extreme demands made upon them. The same general thesis may probably be, with equal force, maintained in connection with structures. Only by the introduction of new materials, first cast-iron, then wrought iron, mild steel, high-tension steel wires, reinforced concrete and, finally, alloy steels, all of which have been used for structural purposes, have made possible the colossal structures of the nineteenth and twentieth centuries; and future progress will probably not depend so much upon the discovery of new principles of construction as upon the perfecting of the methods of working and using the known materials and the discovery of new materials.

In the first paragraph of the very important work under review the author, Professor C. F. Jenkin, remarks, "In no branch of engineering is an accurate knowledge of the strength of materials so important as it is in aeronautics, where the weight of every part has to be reduced to the minimum compatible with safety." This was clearly recognised by Professor Jenkin very early in the war, and as the responsible officer for specifications for aircraft material for the Admiralty, he saw how very necessary it became not only to know as fully as possible the final behaviour of materials under all kinds of stress, but also how the conditions of working and of failure were related to the fundamental properties of the materials. This important volume contains accounts of researches undertaken by many workers, in connection with all kinds of aircraft materials, and it is not too much to say that no more important contribution has been made to the literature of the subject of materials for many years. Lack of space forbids any detailed examination of the contents of the volume before us, but it can at once be said that the material it contains is by no means important with relation to aeroplanes and aeroplane engines only. The effect of temperature, tempering and normalising, on the properties of steels of many kinds and also upon the properties of cold worked steels, receives very considerable attention. The ranges of repetition stresses and the relationship of the repetition range to the elastic properties of the materials, and also the effect of heat treatment upon these properties and the impact factor, are very fully dealt with.

There is an interesting and suggestive chapter upon the effect of changes of section, screw threads, sharp corners, scratches, key-ways, and castellations in causing local concentrations of stress and experimental data is given in another chapter of actual failures of the parts of engines. The structure of steel ingots before and after working and forging, is illustrated by macrographs and micrographs. The chapters dealing with the steels used in engines is followed by an important chapter on steel tubes, the effect of heat treatment upon their properties being very fully discussed. Chapters V and VI are devoted to stream line wires and ropes, and very important data is given in connection with these troublesome aeroplane elements. Then follows a chapter on cast aluminium alloys as used for pistons and cylinders of aeroplane engines, and also some particulars are given of tests of the wrought aluminium sections used for rigid airships and for other structural purposes. A good deal of data on the effect of temperature on the breaking strengths and hardness of various kinds of alloys is given, and also upon the effect of repetition stresses upon these alloys. The copper alloys used for aeroplane seats and other purposes made it desirable that the properties of these should be investigated, and curves of breaking strengths and hardness at various temperatures are given. Some reference is also made to "white metals" and to solders and fluxes. A brief chapter on corrosion is followed by a chapter dealing very completely with the fundamental properties of timber and descriptions of experiments carried out in connection with wing spars, propellers and struts. The extraordinary variations in the properties, not only in different samples of timber of the same kind, but also in different directions in the same piece, makes it of the greatest importance that the fullest experimental data of the behaviour of timbers should be obtained and the theory of assytropic materials worked out. This chapter is a very distinct contribution to this important subject. Other chapters on glue, rubber-shock-absorber chord, and fabric, bring the book to a close. At the ends of the chapters are appendices giving specifications for the various materials and discussing points of theory.

The book is a most valuable compilation of experimental work and of investigations carried out during the stress of war, by a number of workers who evidently brought to their task much devoted labour and experimental skill. The author has most generously acknowledged in all cases his indebtedness to these, and engineers are placed under a deep obligation to him, to all those who have assisted him and have carried out the experimental work, and to the Air Ministry for allowing the publication of this most valuable contribution to the all-important subject of materials.

Handbook of Metallurgy. Vol. I. *Copper, Lead, Silver, Gold.* By Dr. CARL SCHUARLE. Translated by HENRY LOUIS, M.A., D.Sc. Third edition, revised. London: Macmillan and Co., Limited. [Price, 40*s.* net.]

ORIGINALLY published in this country in 1898, this book has been ever since the standard text-book, on the general metallurgy of the non-ferrous metals, and it has proved its value to students and to all those who are engaged practically in the industry. The previous two editions became exhausted, and the third edition was prepared in 1914, but is only now being published owing to the war.

In preparing this new edition Professor Louis has taken the opportunity to revise a considerable amount of the letterpress and to bring the general information and descriptions up to date, at the same time cutting down or modifying the space given to processes now obsolete or little used. It is doubtful whether this treatment could not have been carried on to an even greater extent with a further improvement in its usefulness, and certainly a reduction in the size of the book. Obsolete processes described in detail are of little interest to the student—he merely wishes an outline of the principles involved, but should the occasion arise for him to consult the details, the earlier editions of this book are available, and there are other authorities as well. Again, all the references which occur to costs of treatment in different parts of the world could well be omitted since they no longer possess any value—and they are fast losing even a relative significance with regard to present-day standards. It would therefore seem a pity that the revision o which the original has been subjected had not been more drastic.

In this volume the metallurgy of copper, lead, silver and gold receive a full treatment, and the processes described so minutely are illustrated by a large number of engravings and diagrammatic drawings so that there is never any doubt as to what the author wishes to portray. It is this singular clearness of exposition which has helped to make this work so popular. In dealing as it necessarily does with a vast amount of detail information the tendency to adopt a stereotyped mode of expression and description is strong, but it can be said, and let it be gladly recorded, that the translator has avoided completely any suggestion of tediousness, and he has maintained the interest for the reader by the freshness of his own outlook.

Metallurgists who already have the previous editions will find this new volume a very necessary addition to their bookshelves, as it continues to be unquestionably the standard work of reference on all questions concerning the metallurgy of the non-ferrous metals with which it deals.

BOOKS RECEIVED.

Steam Boiler Maintenance. A Concise Treatment of First-Class Practice in the Maintenance Overhaul and Inspection of Boilers and their Accessories. For Boiler Attendants, Mechanics, Students and others. By REG. CLAYTON. London: Sir Isaac Pitman and Son, Limited. [Price 2*s.* 6*d.* net.]

Cours Pratique de Chauffe et de Chaudières Industrielle. Par ED. JOLLY. Paris: Dunod. [Price 22 francs.]

Liquid and Gaseous Fuels and the Part they Play in Modern Power Production. By VIVIAN B. LEWES, F.I.C., F.C.S. Second Edition. Revised and edited by JOHN B. C. KERSHAW, F.I.C., F.S.S. London: Constable and Co., Limited. [Price 12*s.* 6*d.* net.]

Modern Motor Car Practice.—Edited by W. H. BERRY. London: Henry Frowde and Hodder and Stoughton. [Price 31*s.* 6*d.* net.]

THE INSTITUTION OF BRITISH FOUNDRYMEN.—The opening meeting of the winter session of this Institution will take place on October 1, in the College of Technology, Manchester, when the president, Mr. W. H. Meadowcroft, of Tyldesley, will deliver an address. Subsequently, six meetings will be held during the session, commencing on November 5 with a paper on the "New White Metal Series," by Mr. J. D. Paton. Other subjects will be Jar Ram Moulding Machines; Foundry Accounts; Cupola Practice; Plaster Patterns; the Manufacture of Coke for Industrial Purposes. The annual dinner will be held on January 14, 1922, and the annual meeting on May 6. The meetings take place at 4 p.m. An annual conference will be held in Birmingham next year.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—The 1921–22 session of this Institution commences on the 14th prox., when Sir William Joseph Noble, Bart., will deliver his Presidential Address. Notable items in the early part of the programme provisionally arranged include a paper by Major-Gen. Sir Sefton Brancker, K.C.B., on the present position of aviation, to be read on the 19th prox.; and a paper on sea casualties and loss of life by Sir Westcott S. Abell, K.B.E., to be given on November 4. Sir Eustace H. T. d'Eyncourt, K.C.B., F.R.S., will also read a paper on December 2 on a subject to be announced later, while Sir Vincent L. Raven, K.B.E., will deal with the subject of railway electrification on December 16. The growing importance of the marine oil engine may be gathered from the fact that four papers relating to this method of ship propulsion form part of the programme for the new year. The first of these papers relates to the use of compressed air in Diesel engined ships and is by Mr. W. Reavell, while the others, which are entitled "Marine Diesel and Marine Oil Engines," "Running Costs of Diesel-Engined Ships," and "Diesel Engine Design," are by Mr. K. O. Keller, Mr. T. Madsen and Mr. Paul Belyavin respectively. The above-mentioned papers do not include the whole programme so far arranged, and other papers are also under consideration by the Council. Further particulars can be obtined from the Secretary, Mr. E. W. Fraser Smith, Bolbec Hall, Newcastle-on-Tyne.

"STRESSES IN SHIPS' PLATING DUE TO FLUID PRESSURE."

TO THE EDITOR OF ENGINEERING.

SIR,—Professor T. B. Abell's criticism of my paper in ENGINEERING of the 16th inst., relating to stresses in ships' plating, read before the British Association in Edinburgh recently, seems to suggest either that he has not entirely grasped the details of the communication or that I have not made them clear.

At any rate, the communication itself is but a particular part of a broad scheme of investigation, on which I have been engaged for a number of years, but while it naturally finds application to many problems such as that associated with the design recently produced by Professor Abell, the principles contained therein have no particular relation to that design, nor to my professional work with Lloyd's Register, but are based entirely upon the lengthy inquiry already mentioned.

The real points raised by the Professor relate to that part of the paper dealing with the question of "plates reinforced by stiffeners with free ends" and seemingly refer to :—

(1) The meaning of Fig. 6.
(2) The value of the stress at the ends of the stiffener.
(3) The influence of a change in the length, upon the stress at the ends, of the stiffener.

First.—Fig. 6 is *purely diagrammatic*, and therefore *not being drawn to scale*, Professor Abell is not justified in his interpretation. The figure illustrates *only in a general way the qualitative relation* between the principal stresses along the edge of the rectangle under certain indicated conditions. That relation naturally will vary according to the particular values given to l and r, *e.g.*, if $l = r = 1$, the relation between $f(n)$ for $\frac{2l}{r} = n$ and $\frac{l}{r} = n$ is as 5 : 2, a ratio approaching that found by the Professor in reading off the maximum ordinates to *scale*.

Second.—The inferences relating to the stress at the ends of the stiffeners are naturally drawn *not* from Fig. 6, but from Figs. 4 and 5, which show, graphically to scale, the results of specific calculations.

This problem whittles down to the question as to what amount of plating may be taken to act jointly with the stiffener in looking at it from a beam standpoint. Can the whole of the plating between the successive stiffeners be generally taken? I think not. Can, say, 3½ in. be taken? It may be so, perhaps more. One cannot definitely decide from theory. That is why Figs. 4 and 5 were introduced to indicate the variation of stress with width of plating.

At the risk of reiteration I may say it was pointed out in the paper that although the stress at the free ends of the stiffening bars is not exactly calculable, yet it may be considerable under certain conditions where, *e.g.*, the plate area is large and the stiffeners widely spaced, and, further, that although the stress may be sufficiently reduced by a close spacing of stiffeners, yet the spacing may require to be so close as to render the proposition uneconomical or undesirable. Professor Abell therefore opens no new vista when he says that stress is reduced by stiffening the plate—this was clearly set out in my paper. The question rather is—can the stress be sufficiently reduced by an economic introduction of reinforcement?

In the present state of knowledge it is obvious that the answer to such a question must be one of opinion only.

Third.—With reference to the influence upon stress, of varying the length of the stiffener relative to the free span of the plate, this may be solved by the aid of the expressions given in my communication to the *Phil. Mag.*, vol. xlii, referred to in my paper. Thanking you for your courtesy,

I am, yours faithfully,
B. C. LAWS.

LARGE GAS ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—We desire to make a protest against the custom, unhappily too common, of citing the productions of Continental countries as representative of the most advanced practice in engineering, and ignoring the fact that examples of similar or better practice may also be found in this country. For example, Dr. S. P. Smith, in a British Association paper on "Large Electric Units," referred to in your issue of September 23, draws his examples of large internal-combustion engines for power generation entirely from Continental firms, making no reference whatever to the engines of these types made by British firms.

We are afraid that this is merely one instance of a very prevalent tendency to ignore or even belittle British engineering progress. Surely in a paper read under the auspices of the British Association, at any rate some indication should be given that Continental firms are not the *only* ones to whom one must go for examples of large gas and oil engines.

For the writer of a paper such as the one mentioned to be unaware that there are British firms who build large internal-combustion engines, is most regrettable. One need only consult the columns of the engineering press for the last few years to realise that British firms are not inactive in this direction, yet judging from the list of firms whom Dr. Smith quotes as supplying information for his paper he does not seem to have even approached British makers of gas and oil engines for this purpose.

While we do not in any way wish to decry the skill and enterprise of foreign engineers, we do think that many British writers on engineering subjects by directing attention to foreign rather than to British achievements are conveying a false impression as to the state of engineering progress in this country, and doing thereby an injustice, and possibly an injury, to British engineering.

Yours faithfully,
GALLOWAYS, LIMITED,
H. PILLING, General Manager,
Galloways, Limited, Knott Mill Iron Works,
Manchester, September 26, 1921.

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to the paper read before Section G of the British Association at Edinburgh, September 13, 1921, by Mr. Stanley Parker Smith, D.Sc., on "Large Electric Units," we notice that under the heading of "Large Internal Combustion Engines" Mr. Smith states that these have been widely developed on the Continent. It seems unfortunate that Mr. Smith does not mention some of the large installations developed in this country, and especially installations consisting of the vertical tandem type of gas engine, which is entirely of British design.

We beg to inform you that during the last six years 65,000 h.p. in vertical gas engine units of between 300 h.p. and 1,500 h.p. were supplied by this firm alone, and are to-day operating under varied and arduous conditions, including driving alternators in parallel, to the satisfaction of their purchasers. These include 11,500 h.p. at a shipbuilding yard, where the current generated is in parallel with the local supply; 11,500 h.p. at an iron and steel works, generating electricity and driving blowers; and 11,000 h.p. at a Government electric power station.

This record from one firm alone, during a war period when normal activities were seriously interfered with, will, we think, challenge comparison with results anywhere in the world in the production of these large power units, and contradicts the suggestion that the large gas engine industry in this country is declining.

Yours faithfully,
THE NATIONAL GAS ENGINE COMPANY, LIMITED.
HY. H. BIRKISTON.

THE LATE SIR JOHN HAROLD HEFFERNAN.

TO THE EDITOR OF ENGINEERING.

SIR,—The death of Chief Inspector of Machinery, Sir John Harold Heffernan, which you recorded on page 452 of your last issue, brings to a close not only a distinguished career, but one that recalls some of the most interesting experiments and developments in naval engineering. Among the ships he served in were the Agamemnon, Warrior, Waterwitch, Spartan and Inflexible, each of which represented some important experiment or advance, and his period of service saw the transition from the old wooden sailing line of battleship with 121 guns mounted on three decks to the heavily-armoured steam-driven steel ship mounting four huge guns, placed in two armoured turrets.

Heffernan's entry into the Service took place towards the end of the Russian War. He had served an apprenticeship with Messrs. Holts, in Long Acre, London, working daily from 6 a.m. to 8 p.m., and in 1855 joined the Navy as a third-class assistant engineer. The grades of engineers were then chief engineer, first, second and third class, and assistant engineer, first, second and third class. A tremendous extension of the steam department of the Navy had taken place during the war, and the authorities were glad to get young and able recruits. Some of the engineers entered at the time possessed but few qualifications, and it is on record that men, practically destitute, were entered at Woolwich yard. There was at that time and for some years afterwards no proper scheme of training and entry, and in 1859 Chief Engineer George Murdock toured the shops of Leith and Glasgow in full dress uniform, inviting young fellows out of their time to enter the Navy. Altogether he secured 103 by this crusade, one of the results being that many of the reforms desired by those already in the Navy received a severe set back.

One of the first vessels Heffernan served in was the Agamemnon, the first wooden line of battleship designed especially to be driven by the screw, and the first screw-driven line of battleship to carry an admiral's flag into action. With the Sans Pareil she took part in the bombardment of Sevastopol. The engine-room complement of such a ship consisted of 7 engineers and 20 stokers, whose duties must have been comparatively light. There was no auxiliary machinery, and, by an order of 1856 their lordships were pleased to direct that "in future the use of steam power shall not be resorted to when the service on which a vessel is employed can be satisfactorily performed without it." These were the days when the Admiral of the North American Station flew his flag in a sailing ship, but was always accompanied by a paddle frigate, which towed his flagship during calms, and was in turn towed herself when winds were favourable.

In 1857 and 1858 the Agamemnon, with the U.S.S. Niagara, carried out the laying of the first Atlantic cable. Each vessel carried half the cable, and though the attempt of 1857 was a failure, the ships met in mid-ocean the following year and, on August 6, the old and the new worlds were connected for the first time by an electric telegraph. For their share in this enterprise the Naval Engineers, some eight in number, received the Gold Telegraph Medal, given by, I understand, an American scientific society. Sir John Heffernan was among the recipients, but much to his regret his medal was stolen some thirty years ago.

Another notable vessel Heffernan served in was the Warrior, our first armoured broadside iron frigate. In this ship and her sister the Black Prince—the horse-power was so much greater than anything that had gone before—there were at first two chief engineers, an arrangement that did not work well and was soon changed. They were both fine vessels, and, according to Admiral Phipps Hornby, "the officers in them were so disgustingly proud of them that they would allow them on faults."

After further experience Heffernan was placed in charge of the machinery of that notable craft the Waterwitch, a double-ended armoured gun-boat fitted with jet propulsion according to Ruthven's plan. Andrew Murray, the first Chief Engineer of Portsmouth, was an ardent advocate of jet propulsion, and the Waterwitch was fitted out under his supervision. Like her sister ships, the Vixen and Viper, the Waterwitch was about 160 ft. long and 1,200 tons. Instead of ordinary machinery, however, she was fitted with a three-cylinder horizontal engine driving a vertical crankshaft, on the lower end of which was an impeller 14 ft. in diameter fitted with 12 vanes and weighing 8 tons. The casing was 19 ft. in diameter. Water was drawn in through a large grid in the bottom of the ship and discharged through two large nozzles placed on either side of the ship just above the water line. The nozzles, each of which had an area of about 5 sq. ft., could be reversed and, as the vessel had a rudder at each end, she could steam equally well in either direction. It was while in this vessel that Heffernan was promoted for his action in saving his vessel from foundering. This was in 1868, and his name then for the first time appeared in the Navy List.

In June, 1870, just when the controversy over the merits of the compound engine was at its height, he was appointed to the Spartan, one of the five vessels—the others being the Thetis, Tenedos, Briton and Sirius—fitted with compound engines of various types. Of all the engines ever supplied to a man of war those in the Spartan were perhaps the most extraordinary. The brilliant young students and fellows of the Royal School of Naval Architects and Marine Engineering made great play over these engines, which certainly were not designed to give the ships' staffs much confidence. One writer in the "Annual" of the school for 1872, referred to them in these terms, "When it takes six men six days to open up, and when opened up the trunk is found to strongly resemble corduroy in its scored appearance, the design cannot be called a success; nor is it an advantage in an engine to be obliged to use the hand turning gear before a start can be effected when the ship is going end on to a hulk." Another writer in the same journal gave particulars of the engine. "Each engine has a long cylinder of 64 in. diameter, divided by a diaphragm into two equal parts. There are two pistons of the same diameter as the cylinder connected together by a trunk, 55 in. diameter, which works through a gland in the diaphragm, metallic rings being used for the packing. The high-pressure steam acts on an annular surface, 4½ in. wide, area of which is to piston as 1 : 4, and this is the ratio of the volume for high pressure and low-pressure steam in this cylinder." So little were the principles of thermodynamics understood at the time that the same cylinder was made to serve first for the high-pressure steam and then for the low-pressure steam. This was the engine which for about five years Heffernan had to contend with, and it is no wonder that when giving evidence before Admiral Astley Cooper Key's Committee in 1875, when asked, "was there anything special in the engine of the Spartan which made it require more than usual care?" He replied, "Yes, they were very troublesome, they were compound engines of a peculiar type and very troublesome to manage."

The committee referred to was appointed in 1875 to consider "how the most scientific and practical management of engines, and the highest mechanical skill for their maintenance can best be secured for Her Majesty's Navy," and the report is not only of great historical value, but is worth reading for the light it throws upon the social standing of the engineer in those days. Many of the witnesses were shown a list by the president. This list apparently enumerated the callings of the fathers of candidates for entry into the Service as engineers, the occupations varying evidently from "Soldier, sailor, tinker, tailor" upwards. When the list was shown to Heffernan he remarked, "Personally I have no fault to find with them, but as the father of boys, I certainly should not bring up one of my own sons as engineer unless they had a better prospect held out to them," and to a further question, he replied, "A man does not feel that his son ought not to become a paymaster, but I feel that mine ought not to become an engineer under the present regulations."

At this time Heffernan was chief engineer of the troopship Crocodile, then in her prime, but in February, 1876, he was appointed to oversee the building of the famous Inflexible, at Portsmouth, and this proved to be his last seagoing ship, for she was commissioned by the late Lord Fisher, and Heffernan received his promotion to Inspector of Machinery soon after the bombardment of Alexandria in July, 1882. The Inflexible, even more than the Warrior, the Waterwitch or the Spartan, was an experiment and an advance. In the words of Sir Edward Seymour, who succeeded Lord Fisher as captain, she was five things, viz., "the largest ship in the Navy, being the only one of 10,000 tons, she was also considered our most powerful fighting ship, and she was the only one that cost 1,000,000*l.*; she was also certainly the most complicated vessel and was the first man-of-war illuminated by electric light." It may be added that among the innovations in the Inflexible were submerged torpedo tubes which could be trained, the only ones ever so fitted. Heffernan subsequently served as chief engineer of Bermuda Yard, and as the principal engineer officer on the staff of the Admiral at Portsmouth. In 1891 he had the distinction of being the fourth engineer officer in the Navy to receive the C.B., his predecessors being Inspector of Machinery G. G. Bardin, who received it in 1868, Thomas Baker 1869 and James Roffey 1882. As stated in your obituary notice last week, the knighthood was conferred upon him ten years ago.

Yours faithfully,
"HISTORICUS."

THE EXTRUSION DEFECT.*

By R. GENDERS, M.B.E., B.Met., A.I.C., Member. (Communication from the Research Department, Woolwich.)

ALTHOUGH the possibility of extruding soft metals such as lead and tin had been established as early as about 1800, the process was not successfully applied to copper alloys until it was shown by Alexander Dick, during the eighties, that delta metal could be extruded in a heated state. The hot extrusion process, as is well known, consists in the pressing of metal heated to a plastic state, through a die, so that a continuous bar of the cross-section of the die is produced. In the process, as generally carried out, a cast billet, reheated, in the case of 60 : 40 brass, to a temperature of about 800 deg. C., is placed in a receiver having a fixed die at one end. A plunger actuated by an hydraulic press is inserted. As the plunger moves forward the brass is extruded through the die. The advantages of the process are well recognised. The available literature on the subject is scanty and mainly devoted to the design of the apparatus, rather than to the behaviour of the metal during the process.

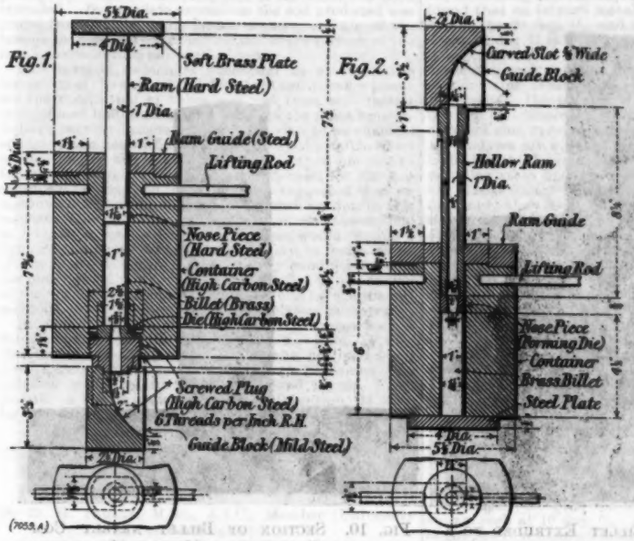


FIG. 3. TRANSVERSE SECTION OF EXTRUDED ROD SHOWING THE CHARACTERISTIC FORM OF THE DEFECT. ETCHED WITH AMMONIA. SLIGHTLY LARGER THAN ACTUAL SIZE.

FIG. 4. LOOSE CORE IN FUZE BODY DUE TO EXTRUSION DEFECT.

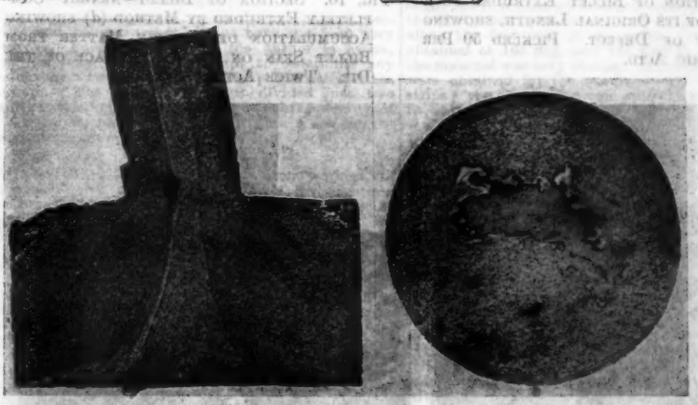


FIG. 5. SECTION OF PARTIALLY EXTRUDED BILLET SHOWING FORMATION OF DEFECT. PICKLED 50 PER CENT. NITRIC ACID. TWICE ACTUAL SIZE.

FIG. 6. TRANSVERSE SECTION OF ROD EXTRUDED ON SMALL SCALE. PICKLED 50 PER CENT. NITRIC ACID. FIVE TIMES ACTUAL SIZE.

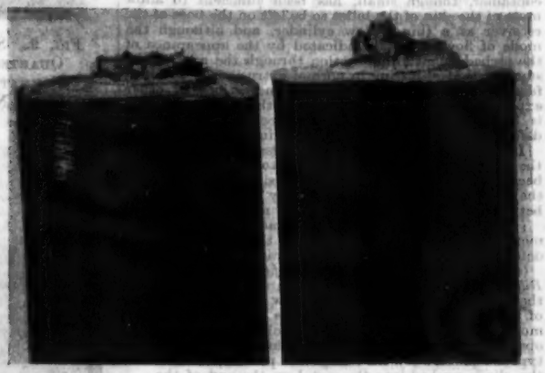


FIG. 7. FRACTURES OF DEFECTIVE EXTRUDED BRASS ROD. ACTUAL SIZE.

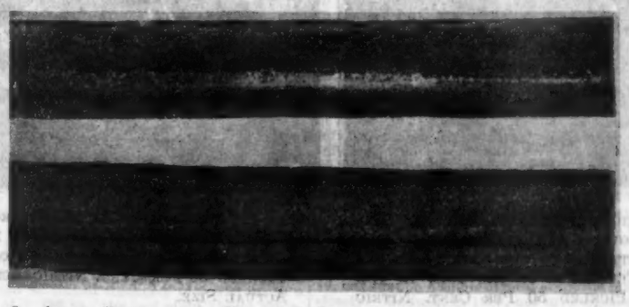


FIG. 8. AXIAL SECTIONS OF EXTRUDED ROD CONTAINING THE DEFECT, EXTRUDED ON SMALL SCALE. PICKLED 50 PER CENT. NITRIC ACID. TWICE ACTUAL SIZE.

I. THE DEFECT AND ITS FORMATION.

It is found that when solid rod is extruded from a central die, the last 25 per cent. or 30 per cent. of rod to leave the die contains a characteristic defect peculiar to extruded rod. Transverse sections show a more or less complete circle, varying in diameter at different positions along the rod, consisting of oxide and foreign matter enclosed in partially dezincified brass. The core inside the circle has generally the same structure as the sound metal outside. A section of a rod containing the defect is shown in Fig. 3. When a defective rod is broken across, the core frequently breaks at a different point from the outer ring and projects, and is sometimes quite loose. Typical examples are shown in Fig. 7. Fig. 4 shows a remarkable specimen of the defect found in a fuse body; in this instance the core is not central, and there appears to be very little foreign matter round it. The defect may not be completely continuous either longitudinally or circumferentially, and it is possible for a badly defective rod to show an end fracture which is not visibly unsound. The defect is commonly known by the misleading term "piping," and has often been ascribed to ingot defects. The sole fact that it occurs regularly in the same form in each rod produced by central extrusion is sufficient, however, to discount this assumption.

The mode of formation of the defect was investigated by the examination of billets extruded to various stages. The specimens were sectioned axially and pickled in 50 per cent. nitric acid. It is found in such specimens that the foreign matter and dezincified metal, similar to that dividing the core from the outer ring in the bar, is present in the partially extruded billet in the form of a funnel. The mouth of the funnel is the edge of the rear end of the billet, and the neck of the funnel is continuous with the tubular defect in the extruded rod, while the metal within the funnel is sound. The occurrence of the defect in this form can be explained as follows. When the heated billet is placed in the relatively cool receiver and expanded into close contact by the first pressure of the ram, the outer surface is chilled and becomes less plastic than the interior. The plastic interior flows easily through the die, but the stiffer outer shell cannot flow so readily, and the friction between the bore of the receiver and the surface of the billet also tends to prevent the skin of the billet from flowing. Consequently the cylindrical skin of the billet, which must shorten as the billet becomes smaller, is bent over inwards to be carried forward by the flow of the metal towards the die. The actual defect thus appears to consist of the dirty, oxidised skin of the original billet, and, if formed in the manner suggested above, would be expected to take a path identical with the outline of the defect found in the sectioned billets. A section of a billet extruded down to a quarter of its original length is shown in Fig. 9. The formation of the defect in this manner explains its occurrence in the rearmost portion of the extruded rod. It is clear that the skin of the billet at its extreme rear end could not enter the die before the reduction in length of the billet well exceeded 50 per cent. It would appear that the defect is present in the rear portion of all rod centrally extruded by the usual methods, but in rod of small diameter the foreign matter may be distributed over

* Paper read before the Institute of Metals, at the Birmingham meeting, September 22, 1921.

such a great length as to render it discontinuous and invisible in the fracture. In many cases the section of a partially extruded billet shows much more foreign matter on one side of the funnel formation than on the other, and in many sections of bar the circle of defective material is incomplete. This can be accounted for by assuming that the ram has not been concentric with the receiver, moving along nearer to one side than the other and thus largely missing the billet skin for a portion of the circumference. The author's explanation of the formation of the defect agrees with the conclusion arrived at by A. E. and P. A. Tucker, in a paper read before the Birmingham Metallurgical Society on March 13, 1919, that the defect was a mechanical issue of extrusion, but gives no support to their suggestion that segregation and the crystalline structure of the billet are factors affecting the occurrence of the defect.

II. Methods of Avoiding Formation of the Defect.

Several remedial methods can be suggested, based either on the prevention of the entry of the skin of the billet into the metal, or on a change in the mode of flow in the system. Possible methods are :—

(*a*) *To Avoid Chilling the Surface of the Billet when Extrusion Begins.*—This is not a hopeful method, since it would necessitate a hotter receiver or a cooler billet, and the effect of friction at the surface would remain.

(*b*) *To Trap the Skin at the Rear End or to Provide an Outlet.*—Alteration to the shape of the end of the ram to that of a dome, or the provision of an annular recess at the edge, might be effective in collecting the billet skin for some period of the extrusion. Difficulties would probably be involved, however, owing to the expanding action of a ram shaped in such a manner. The employment of a ram somewhat smaller in diameter than the receiver would probably avoid the skin of the billet and leave it as a skull in the receiver or partially extrude it rearwards. An effect of this kind may be noted in the sections of billet, extruded on a small experimental scale, illustrated in Fig. 11. The clearance between plunger and container, though small, has been sufficient to allow most of the skin of the billet to be left on the bore of the receiver as a thin hollow cylinder, and although the mode of flow of metal, indicated by the appearance of the etched longitudinal section through the axis, is the same as that occurring in normal extrusion on a manufacturing scale, and confirms the indications of other experiments as to the way in which the extrusion defect is formed, the rod produced is free from the actual defect owing to the escape of the skin of the billet.

In actual manufacture, the process of excluding the skin in this way might prove not to be economical because of the wastage of metal, since to secure the required effect regularly a fairly large clearance between ram and receiver might be necessary.

(*c*) *To Extrude through an Eccentric Die.*—This method would tend only to change the form of the defect and possibly to delay its entrance to the die.

(*d*) *To Avoid Relative Movement of the Receiver and Billet.*—This suggestion is based on the theory that the skin of the billet refuses to flow along the bore of the receiver, and is bent inwards by the forward motion of the ram. It could only be put into operation by substantial modification of the usual type of plant. By inverting the process so that the die is pushed into the metal on the end of the ram, the flow of metal would take place near the die and the skin of the billet at the end farthest away would not be affected, the relative movement being solely between the die and the receiver. It might be possible to extrude both ends at once. This method was patented several years ago, but was devised with the object of obtaining more regular properties in the rod by extruding the middle portion of the billet (which is away from the cooling influence of the die and ram) last. A somewhat more practical method, however, is to carry the die on the end of a hollow ram or to allow the receiver to move forward with the ram, the die being held on a fixed hollow shaft.

It might be objected, however, that the effect of pushing the die into the container, which with the billet remains stationary, would be to turn over the skin of the billet at the die end and allow it to flow into the extruded rod from another point. The turning inwards of the skin at the external edge of the die would undoubtedly occur, but the defective material would accumulate in a region from which smooth flow through the die would be difficult. It will be seen that experiments described below confirm this view.

III. Small Scale Experiments.

Method (*d*) seemed to be the most likely to give freedom from the defect. Small scale experiments with wax are frequently useful for the purpose of indicating the direction of flow under various processes, but cannot be comparable with large scale work on metals, as regards the effects of friction and the pressure required for the operation of different forms of apparatus. Consequently, in the experiments undertaken, brass of 60 : 40 composition was used, under conditions closely approaching those obtaining in commercial manufacture. Considerations such as the amount of power available and cost, governed the size of the apparatus and, since only vertical presses were at hand, modifications were made to enable the extrusion to be carried out vertically. The apparatus for extruding by the method generally used is shown in Fig. 1. The brass was melted in lots of 7 lb., and cast into billets 1⅛ in. in diameter and 6½ in. in length. A discard of 1¼ in. was taken from the top, leaving the billet for extrusion 5 in. in length. The rod was extruded through a central die ½ in. in diameter. To carry out an extrusion, the receiver, with die and screw plug in position, heated to about 500 deg. C., was placed on the slotted guide block, and the brass billet, at a temperature of 800 deg. to 820 deg. C., was inserted. The nose-piece was placed behind the billet, the centreing block placed on the top of the receiver, and the ram inserted. Pressure was applied until rod was extruded at a rate representing the complete extrusion of the billet in about 1 minute. The pressure recorded by the gauge on the hydraulic press during extrusion by this method varied between 700 lb. and 1,500 lb. per square inch, generally rising rapidly towards the later stages. On completion of the extrusion, the screw block was taken out and the guide block replaced by a hollow steel cylinder. Renewed pressure on the ram then discharged the unextruded portion of billet with the rod intact. In complete extrusions (leaving only 4 per cent. or 5 per cent. of the billet unextruded) the defect could be traced on axial sections along 25 per cent. of the extruded rod. The pickled section of a partially-extruded billet shown in Fig. 9 contains the extrusion defect in its characteristic form, and illustrates clearly the progression of the billet skin as it is turned inwards and travels towards the die. The flow lines throughout the billet are in funnel form.

An example in which the formation is more regular and more strikingly shown is seen in Fig. 8. Axial sections of the rod produced contained the defect in the same form as found in large scale production. Typical sections are shown in Figs. 6 and 8. In one of the rods, eccentricity of the ram has produced an incomplete tube of foreign matter which is seen as a single defect in the section.

Since the results obtained by the small scale experiments appeared comparable in every respect with those obtained in manufacturing practice, the apparatus was modified to extrude by the method (*d*), in which relative movement between the billet and receiver is avoided. The design is shown in Fig. 2. To carry out an extrusion, the heated receiver was placed on a base-plate and the billet at 800 deg. C. inserted. The die, centreing plate, and ram were adjusted as before, and on top of the ram was placed the slotted guide block. The pressure recorded on the gauge varied between 400 lb. and 800 lb. per square inch, only occasionally rising to a higher figure, and was on the whole much less than that required for the previous method under the same conditions. On completion of the process the entire apparatus was

Fig. 9. Section of Billet Extruded to a Quarter of its Original Length, showing Formation of Defect. Pickled 50 Per Cent. Nitric Acid.

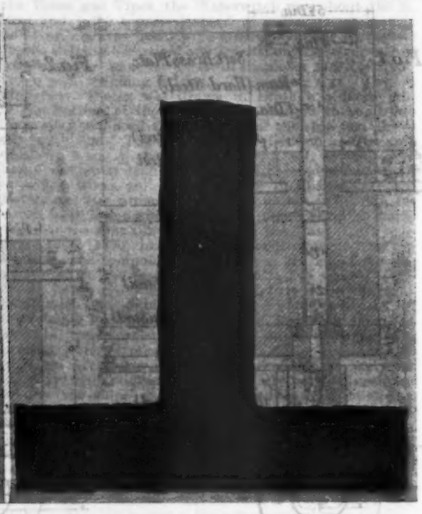


Fig. 10. Section of Billet nearly Completely Extruded by Method (*d*) showing Accumulation of Foreign Matter from Billet Skin on the Inner Face of the Die. Twice Actual Size.

Fig. 11. Section of Billet Partially Extruded showing Direction of Flow. Foreign Matter from the Skin is Absent owing to Clearance of the Ram in the Receiver. Pickled 50 Per Cent. Nitric Acid. Twice Actual Size.

Fig. 12. Section of Billet Extruded to a Quarter of its Original Length by Method (*d*) showing Region and Direction of Flow. Pickled 50 Per Cent. Nitric Acid. Twice Actual Size.

lifted on to a hollow cylinder and pressure reapplied to liberate the unextruded portion of the billet. Partially extruded billets, sectioned and pickled in 50 per cent. nitric acid, are shown in Figs. 10 and 12. It will be seen that the crystalline structure of the billet shows the effects of work only in the region just forward of the die, and that the dirty skin of the billet is gathered on the under face of the die, where the metal appears to remain practically "dead" until the rest of the billet has been extruded. In complete extrusions the rod produced was sound from end to end. In some cases, a little of the foreign matter was extruded on the outer surface of the last 4 per cent. or 5 per cent. of rod.

This method, which is successful in avoiding the formation of the extrusion defect, is in use in many places for the production of tubes and rod from soft metals such as lead and aluminium, although the plant appears to have been so designed only with a view to mechanical efficiency and not with any appreciation of possible effect on the quality of the product. The method has not so far, to the author's knowledge, been used for the hot extrusion of copper alloys, and it is suggested that its undoubted advantages merit some consideration in this respect. The power required is less than with the method at present in use, and thus the process would require a lighter receiver or would be less likely to bulge those of the present type. The necessary modifications of the plant would probably be fully justified by the saving of the very large amount of metal, which by the present method is extruded only to be ultimately scrapped.

In conclusion, the author wishes to express his indebtedness to Mr. H. Moore, O.B.E., B.Sc., F.I.C., director of metallurgical research, who conducted the investigation in its initial stages and has since contributed many helpful suggestions, and to Mr. E. F. Newell, A.R.S.M., and Mr. B. R. Davidson, M.Met., for assistance in the experimental work.

THE RELATION BETWEEN MECHANICAL PROPERTIES AND MICROSTRUCTURE IN PURE ROLLED ZINC.*

By D. H. INGALL, M.Sc., A.I.C., Member (University of Birmingham).

PREVIOUS investigations upon the mechanical properties and microstructure of zinc have not been very numerous. Further, so far as the author is aware, there has only been one attempt to determine any relationship between the mechanical properties and the structure. The present paper is divided into two sections: the first portion contains a brief survey of previous work, and in the second portion is set out the results of the present research.

SECTION I.

Previous Work.—The results of former workers, in comparison with those of the present investigation, may perhaps best be considered by studying specific properties in turn, rather than by reviewing each research in order. Hence the following subsections will be considered: (*a*) Mechanical properties; (*b*) microstructure; (*c*) relation of mechanical properties of microstructure; (*d*) theoretical considerations.

(*a*) *Mechanical Properties.*—In this subsection are included elastic limit, yield point, tensile strength, modulus of elasticity, elongation, reduction in area, and hardness. Some of these tests have been carried out on cast and rolled zinc of different qualities, not only at atmospheric temperature, but also at elevated and at low temperatures. In addition to the above, other physical and mechanical tests have been recorded which are briefly mentioned later. Bauschinger, in 1887, made tests for maximum load, breaking load, contraction and elongation on 15 cm., on pieces of Silesian sheet zinc cut parallel to the direction of rolling. The sheet was about 0·028 in. thick, but no analysis was given. The pieces were pulled at different speeds, and he found that the breaking load was about 80 per cent. to 90 per cent. of the maximum load, figures for which were from 10·7 to 13·4 tons per square inch. The reduction in area remained fairly constant with varying speeds, but the elongation (10 per cent. to 20 per cent. on 15 cm.) varied for unknown reasons. Martens, in 1889, found that he could not test zinc by ordinary static loading, as it was so much influenced thereby. He found that there was a stretch for each load, so he made a machine whereby he could vary the rate of loading. From preliminary tests on specimens cut from a plate rolled in one direction to a thickness of 0·213 in. containing about 1·00 per cent. lead and 0·08 per cent. iron, and from tests on other material, Martens concluded that rolled zinc showed no true elastic behaviour, and obtained a permanent set after each stage of loading even with minute increments of load. He made further tests with various sheets, including a series of 11 plates or sheets, each representing a stage during rolling down from an initial thickness of 0·220 in. to a final thickness of 0·186 in., the last eight sheets representing pack rolling. The analysis of the material was approximately 1·00 per cent. lead and 0·02 per cent. iron. Test-pieces were cut from both major directions, but sizes are not given. Five or six tests were made to obtain an average and eliminate, as far as possible, external influences. In general, the results showed tensile strengths from about 8·0 to 12·5 tons per square inch with elongations of 12·2 per cent. to 22·0 per cent. on 100 mm., with tests cut parallel to the direction of rolling. At right angles to the direction of rolling tensile strengths were from 8·5 to 12·0 tons per square inch, and corresponding elongations from 14·2 per cent. to 17·8 per cent. on 100 mm. The testing of very thin sections was found to give erratic results. Other more complicated data were also deduced. Meyer, in 1905, tested material of varying analysis, paying particular attention to the elastic limit, modulus of elasticity, and limit of proportionality, but obtained disappointing irregular results. He also tried material which had been treated in acid (lithographic work), but found that the effect of the acid was nil. Haines, in 1911, carried out elevated temperature tests in a bath of castor-oil, measuring the extensions with a cathetometer. He found that an impure metal became remarkably soft at 80 deg. to 90 deg. C., and also at 150 deg. C. A little above 90 deg. C. it hardened so rapidly that at 110 deg. C. it was as hard as at 30 deg. C. but more brittle. This hardening took time to develop. Experiments on bars of pure zinc failed to show changes in the region of 100 deg. C., the only peculiarity being a hardening at 200 deg. C. Moore, in 1915, made tension tests on sheets of rolled zinc varying in thickness from 1·0 to 0·006 in. No analyses are given. He found that zinc possessed a high degree of plasticity, and that either in the cast or rolled state had no definite yield point and a very low elastic limit. The breaking load of this rolled zinc (not more than 0·05 in. thick) was about 10·7 tons per square inch, and the tensional modulus of elasticity about 5,150 tons per square inch. Rolled zinc was stronger across than with the grain, but more ductile with the grain than across it. Mathewson, Trewin, and Finkeldey, in 1919, made tensile tests on four grades of rolled zinc, both as rolled and annealed, at different temperatures. They summarize their results as follows: Hard-rolled across the grain show with annealing a sharp drop from 17·9 to 9·0 tons per square inch at 100 deg. to 125 deg. C. With the grain the corresponding fall is from 15·5 to 7·1 tons per square inch. The percentage elongation on 2 in. also decreases somewhat from about 40 per cent. to 30 per cent. With soft and dead soft material there is practically no change unless cold-work has been done, when the results are erratic. Miss Bingham, in 1920, tested rolled bars of pure zinc at elevated temperatures, and rolled strip (1 mm. thick) annealed and quenched at different temperatures. The results of the former tests showed that the tensile strengths fell steadily from 10·7 tons per square inch at 10 deg. C. A sharp inflection marking a slight rise in maximum strength occurred at 180 deg. C.; the elongation was constant at 60 per cent. on 2 in. along the first part of the curve, two maxima being obtained at 160 deg. and 180 deg. C. At 175 deg. C. the material was very ductile. Somewhat similar results were obtained for the tensile results of the quenched strips; the elongations rose steadily from 30 per cent. to 42 per cent. at 100 deg. C., and at 180 deg. C. there was a sudden fall from 33 per cent. to about 10 per cent. In the discussion Pierce (Palmerton, U.S.A.) wrote that the elongations on the tensile test specimens showed the same ductilities that were obtained at his works with different kinds of rolled zinc measured by the dynamic cupping test. He further stated that they found Miss Bingham's inflection at 170 deg. to 180 deg. C. to vary in position and intensity with the degree of cold-work, disappearing in pure hot-rolled metal. Schulz and Zeller, in 1920, found that annealing forged zinc decreased the tensile strength and elongation. Heating forged zinc to 150 deg. to 200 deg. C. much affected the elongation, and while annealing for half-hour at 200 deg. C. did not appreciably alter the tensile strength, half-hour at 300 deg. C. considerably decreased it.

Hardness determinations have been made on cast and rolled zinc, using the scleroscope, Brinell, and cone-indent methods. Rose, in 1912, using the scleroscope with a magnifying hammer investigated cast, rolled, and annealed zinc. The cast metal had a hardness of 12·5, the rolled 36, and on annealing at increasing temperature a slight fall to 32 was obtained up to 50 deg. C.; at 60 deg. C. there was a decided drop to 26, and from 60 deg. to 100 deg. C. the hardness fell slowly from 26 to 23. Beyond 100 deg. C. the effect was comparatively slight. Mathewson, Trewin, and Finkeldey, in 1919, carried out scleroscope hardness tests during their annealing experiments on the four types of rolled zinc sheet. They found that the hard-rolled with an initial scleroscope number of 28 markedly softened with brief anneals at 75 deg. C., and completely softened (hardness 15) with one hour at 100 deg. C.; higher temperatures had no further effect. Medium hard-rolled with a hardness of 24 began to soften at 100 deg. C., and was completely soft at 125 deg. C. with a hardness of 14. Annealing soft and dead soft sheet gave a slight drop from about 15 to 14. Miss Bingham, in 1920, made both scleroscope and Brinell tests on quenched zinc strip, starting with the material on a completely annealed state. She abandoned the Brinell results, but gave scleroscope figures ranging from 10·2 to 15·2. In the discussion on her paper, Pierce (Palmerton, U.S.A.) contended that in a single sheet of rolled zinc the scleroscope hardness of differently oriented grains varied as much as from 6 to 17, but that on a single crystal grain the readings checked closely. Ludwik, in 1920, has investigated the hardness of alloyed zinc by means of the cone-indent test.

In addition to the above tests experiments have been carried out on compression, torsion, punching, and shearing by Moore; or cold-bending by Mathewson, Trewin, and Finkeldey; on electrical resistance, thermal E.M.F., thermal curves, electrolytic potential and specific gravity by Miss Bingham; on impact strength by Schulz and Fiedler, and also Mathewson, Trewin, and Finkeldey. With regard to the last-named tests it may be pointed out that Schulz and Fiedler employed notched-bar test-pieces, but Mathewson, Trewin, and Finkeldey used a Bliss press with an Ilsen cup and die (the ordinary Olsen machine being too slow), which gave impressions, if desired, in a fraction of a second.

(*b*) *Microstructure.*—The polishing and etching of zinc by previous workers reveal a variety of methods.

Primrose, in 1909, produced photomicrographs of zinc containing iron, but does not state how the material was prepared or etched. Rosenhain and Archbutt, in 1911, working on the alloys of aluminium and zinc, found that the latter was very difficult to polish and was etched with either a 10 per cent. solution of caustic potash or weak nitric acid. As far as the author is aware, Timoféef, in 1912, was the first to investigate the microstructure of zinc in detail. His etching reagent consisted of 94 grammes nitric acid and 6 grammes chromic oxide, of which a few drops were added to 50 c.c. water. Studying the effect of work and annealing on the microstructure of zinc, he found that with a relatively small amount of work the grains of cast zinc were distorted but distinguishable; with much work the grains became indistinguishable and streaks were obtained. Recrystallization commenced very slowly at room temperature after 15 days, on annealing it was not rapid below 100 deg. C.; moreover, the size of the grain was not characteristic for any definite temperature but continued to grow, and the rate of growth increased with rise of temperature. Timoféef further deduced that the speed of recrystallisation did not depend on room temperature only but also on the degree of work, as he found that the grain size in his specimens was larger where there had been most work. Hudson, in 1915, in addition to some etching reagents already mentioned, quotes Gulliver as using a solution of 1 part of iodine, 3 parts of potassium iodide, and 10 parts of water. In Circular No. 80 of the Bureau of Standards, published in 1919, the zinc portion of a section through galvanized iron was etched with a solution of 1 per cent. iodine in alcohol. Mathewson, Trewin, and Finkeldey, in 1919, gave a process for polishing rolled zinc, using various grades of emery powder, and for etching they used a solution made up of 10 grammes chromic acid, 1·5 gramme anhydrous sodium sulphate, and 100 c.c. water. On annealing their four grades of rolled sheet they found that recrystallisation was always of the "exaggerated" type. It was induced in the hard-rolled sheet in a few minutes at 100 deg. C., and at the same temperature after about 1 hour with the medium hard-rolled. Soft and dead soft strip when annealed from 50 deg. to 300 deg. C. merely showed the absorption of small crystal grains by larger ones. Their results are further referred to later in the present paper. Hayes, in 1920, polished zinc with Globe metal polish and removed the grease with water-free ether, owing to difficulty being experienced with staining when using wet methods. His method of etching was to dip in fuming nitric acid, using zinc-tipped tongs, and then wash immediately in water, and dry in hot air-blast. Miss Bingham, in 1920, polished zinc with wet magnesia, and for etching crystal boundaries left the specimen standing in air or warmed a certain amount. She also used an electrolytic etch consisting of 20 drops of concentrated hydrochloric acid in 50 c.c. of alcohol; the specimen was made the anode, and a pressure of 4 volts used. Schulz and Zeller, in 1920, examined the microstructure of annealed forged zinc and found coarse crystallisation developed at a temperature not less than 140 deg. C.

(*c*) *Relation of Mechanical Properties to Microstructure.*—In connection with his work on testing zinc wire at elevated temperatures, Haines noted that the tenacity and ductility of wires heated above 120 deg. C. and cooled were diminished, but could be restored by hammering. The change in properties, on annealing, was accompanied by a development of a crystalline structure. The work of Mathewson, Trewin, and Finkeldey on the annealing of the four grades of rolled zinc was extensive. They found that the changes in hardness, tensile strength, &c., occurred simultaneously with a grain growth of the exaggerated type. They showed that the appearance of this grain growth produced a metal of inferior qualities, and deduced that the properties of a good sheet of rolled zinc depended upon a uniform small grain size which could only be obtained by rolling. Miss Bingham's work on zinc showed that there were changes, on heating, both in structure and mechanical properties. Schulz and Zeller found that the loss of mechanical properties on annealing forged zinc was concurrent with the coarsening of the structure. Further confirmation of a relation of structure to mechanical state has been given by Masing investigating the formation of nuclei in cold-rolled zinc with primary and secondary deformations.

(*d*) *Theoretical Considerations.*—Mathewson, Trewin, and Finkeldey devote a section of their paper to the theoretical side. Their conclusions, based on the results of their investigations and treated mainly from the nature of grain growth as expounded by Jeffries, are interesting with respect to this present research. The following is a brief summary of their conclusions: All metals and solid solutions have an equi-cohesive temperature (Jeffries), *i.e.*, a temperature where the cohesions of the crystalline and amorphous phases are the same. The equi-cohesive temperature is very near that temperature at which spontaneous recrystallisation commences after severe cold-work. Now, whereas with most other common metals and alloys this temperature is well above that at which they are normally worked, with zinc it may be not only very near, but actually below the working temperature. This means that in rolling pure zinc (whose equi-cohesive temperature is practically atmospheric) the conditions of rolling are always those of "hot-working," using the analogy of steel, and that it is hence practically impossible to produce a strain-hardened material, as recrystallisation is always destroying the mechanical hardening. The result is that rolling pure zinc can only give a soft or dead soft sheet. With an impure zinc the effect of the impurities is to raise the equi-cohesive temperature so that a hard or medium-hard sheet may be obtained.

SECTION II.

Present Work.—Before attempting to investigate any relationship between mechanical properties and the

* Abstract of paper read before the Institute of Metals, at the Birmingham meeting, September 22, 1921.

microstructure of rolled zinc, it was obviously necessary to be familiar with the polishing and etching of zinc. When the present work was undertaken the existing information on the polishing and etching of zinc was not extensive, for the work of Miss Bingham and Hayes, &c., had not been published. As a consequence it was resolved that the first portion of the present work should be as full and complete an investigation as time would permit on (1) methods of polishing, and (2) the etching effects of as many different reagents as possible on cast and rolled zinc. A record of the results obtained is set out below, and it is regretted that the data are not still more exhaustive.

Polishing of Cast and Rolled Zinc.—Preliminary trials with the ordinary methods, *i.e.*, finishing after the 0000 emery-paper on wet parchment, or chamois leather with the finest alumina or magnesia—gave poor results from the point of view of both scratches and staining. The procedure advocated by Hayes was partially tried independently by the author, who used Globe metal polish, but could not completely remove the last traces of grease with ether, and the fine films left were fatal for subsequent etching. The best results were ultimately obtained by a combination process as follows: The specimen from the 0000 emery-paper was rubbed lightly on chamois leather with Globe metal polish to remove the paper scratches, leaving some fine ones due to the metal polish. As much grease as possible was removed by water-free ether, and then the specimen was rubbed very lightly on wet parchment with magnesia, in the form of a thin cream, to remove both the fine scratches (as far as possible) and the trace of grease left from the metal polish. The specimen was then washed under the tap, gently rubbing with wet cotton-wool if necessary to remove any adherent magnesia, and was kept wet and immersed in that condition in the etching solution. In this way it was found quite easy to keep the surface free from any staining. Zinc was found to be exceedingly prone to "flow" during the process of specimen preparation, and rolled zinc, though harder than cast zinc, was curiously much the more susceptible to flow. In preparing specimens of rolled zinc it was found that the utmost care and patience were necessary when rubbing on the papers, so as to employ the lightest pressure, otherwise the resulting etch revealed a blurred structure, where the crystal grains were indefinite and appeared smudged. It is not desired to convey the impression that the above procedure is constant and definite. Experience has proved that the results are sometimes variable, as shown by Figs. 4 to 9 on the opposite page. The procedure given proved to be the most satisfactory of all the methods tried. It is regretted that it was not found practicable to try the system of polishing given by Mathewson, Trewin, and Finkeldey.

Etching of Cast and Rolled Zinc.—It was at first thought that a reagent which gave a good etch with cast zinc would behave similarly with regard to rolled zinc, but this was found by experience to be not strictly true. On the above assumption the earlier work on different reagents was carried out with cast zinc which had been marked by a stamp, so that the same portion of surface could be examined each time for comparison. The whole of the reagents were not tried on rolled zinc, as the result of testing the more hopeful of them indicated that a solution which gave a poor etch with cast zinc did not give a better one with rolled zinc. In Table I are set out the most successful reagents tried and the results obtained.

Relation of Mechanical Properties to Microstructure.—As far as the author is aware, there has only been one previous attempt to determine the relationship between the mechanical properties and the microstructure of rolled zinc. This was carried out by Mathewson, Trewin and Finkeldey, who made numerous experiments to ascertain the effect of time and temperature upon the annealing of rolled zinc; but their material consisted solely of various grades of finished sheet, *i.e.*, hard-rolled, medium hard-rolled, soft and dead soft.

It was hence determined that the second portion of the present work should be an investigation into the influence of both work and annealing on the microstructure and mechanical properties of pure rolled zinc.

Six sheets were obtained each from a different stage during the rolling out of one casting, together with a portion of cast ingot. It will be seen from the analysis that the metal possessed a high degree of purity:

TABLE II.—*Analysis of Rolled Zinc.*

	Per Cent.
Copper	0·033
Iron	0·013
Lead	nil
Cadmium	trace
Zinc (by difference)	99·954

The sheets were numbered progressively from 1 to 6 in decreasing order of thickness, the thickest sheet being marked 1 and the thinnest 6. Each sheet was found to have a constant thickness to within 3 or 4 thousandths of an inch, and in Table III are shown the numbers with the thickness and the corresponding percentage reduction by rolling corresponding to the amount of work.

It was decided to carry out tests for hardness, yield and tensile strength; also the ductility as measured by the elongation per cent. and the reduction of area per cent. on the material in the following states:—

— As cast.
A As rolled.
B Rolled and annealed for ½ hour at 100 deg. C.
C Rolled and annealed for ½ hour at 150 deg. C.
D Rolled and annealed for ½ hour at 200 deg. C.

It will be noted that, apart from the metal as cast, there were four distinct series of complete tests which were marked as shown—A, B, C and D.

TABLE I.—MOST SUCCESSFUL REAGENTS TRIED AND RESULTS OBTAINED.

Reagent.	Solution and Concentration.	Reference.	Results.
Air	Polished specimen left exposed to air or slightly warmed	Miss Bingham	Exposure of 30 hours produced no change. On warming, the grain boundaries began to etch, but at a temperature where recrystallisation apparently set in.
Bromine in alcohol	2 per cent.; but solution deteriorates in about 24 hours	—	Fairly good etch with cast zinc, with a curious shading effect on crystal grains.
Chromic acid and sodium sulphate	10 grammes Cr_2O_3 and 1·5 gramme anhydrous Na_2SO_4 in 100 c.c. water	Mathewson, Trewin and Finkeldey	Results obtained were irregular and material stained easily.
Iodine and potassium iodide	1 gramme I_2; 6 grammes KI; 10 c.c. water	Gulliver (Hudson)	Given strength over-etched immediately; diluted gave poor etch. Given solution attacks grain boundaries in cast zinc, which show up clearly on repolishing.
Iodine in alcohol	1 per cent. solution	Circular No. 80, Bureau of standards	Fair etch with cast zinc, but readily stains.
Nitric acid	Fuming	Hayes	Good etch with cast zinc, but misleading for rolled zinc.
Nitric acid and chromic acid	94 grammes HNO_3; 6 grammes Cr_2O_3, add a few drops to 50 c.c. water	Timofeef	Given strength found too strong, but fair etch if diluted about four times. Specimens very prone to stain, especially rolled zinc.
Potassium bichromate and nitric acid	2 per cent. $K_2Cr_2O_7$ in 50 per cent. HNO_3. 1 c.c. made up to about 200 c.c. with water	Solution used in the Department of Metallurgy University of Birmingham	The most satisfactory reagent tried for rolled zinc (*cf.* Figs. 5, 6, 7, 8 and 9) also a fairly good etch with cast zinc (Fig. 4).
Electrolytic Etching with Specimens made the Anode.			
Hydrochloric acid	Up to 0·2 per cent. in water; 2 volts to 4 volts pressure	—	Over-etching with solution above 0·2 per cent. and irregular poor results with weaker solutions.
Hydrochloric acid in alcohol.	20 drops concentrated HCl in 50 c.c. absolute alcohol; 4 volts pressure	Bingham	Given solution over-etched in 5 seconds; but ¼ strength gave good etch with cast zinc.
Nitric acid	Up to 0·1 per cent. in water; 4 volts pressure	—	Good etch with 0·1 per cent. solution. Stronger solutions stain badly.
Sulphuric acid	0·05 per cent. to 10 per cent. in water: 4 volts pressure	—	Good etch with cast zinc.

The following reagents were also tried, but the results obtained were unsatisfactory: Ammonium persulphate, bromine in chloroform, chromic acid, chromic oxide and sulphuric acid, copper ammonium chloride, ferric chloride.

TABLE III.

Sheet Number.	Thickness.	Percentage Reduction by Rolling.
	in.	
1	0·366	77·5
2	0·315	80·5
3	0·232	85·8
4	0·186	88·5
5	0·126	92·3
6	0·069	95·8

In each series the tests were made on the metal in each of the six different stages of reduction. The material for series B was annealed in boiling water, and that for series C and D in molten paraffin wax, the temperature being maintained to within 3 deg. C. either way. After annealing the material was cooled in air.

A brief description of the preparation of the test-pieces, together with some notes on the hardness testing, is given in the appendix.

In all cases tests were carried out on specimens cut from the sheets in two directions:—

1. With the major axis parallel to the direction of rolling and afterwards described as "with" the direction of rolling.

2. With the major axis at right angles to the direction of rolling and afterwards described as "across" the direction of rolling.

Hardness.—Both Brinell and scleroscope hardness determinations were made.

Brinell.—These tests were carried out with a load of 200 kg. (see appendix), which was found by trial to be the most suitable both for a reasonable size of indent and for having a safe margin for giving a reliable hardness number on the thinnest sheet. The results are plotted against the percentage reduction by rolling in Fig. 1.

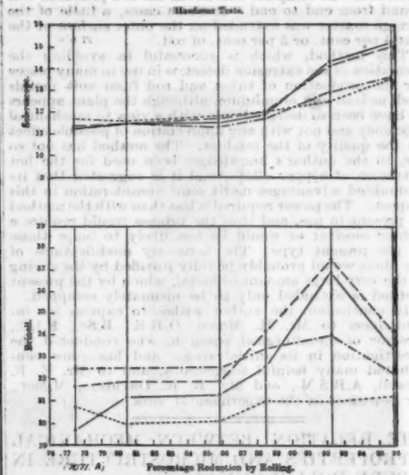


FIG. 1.

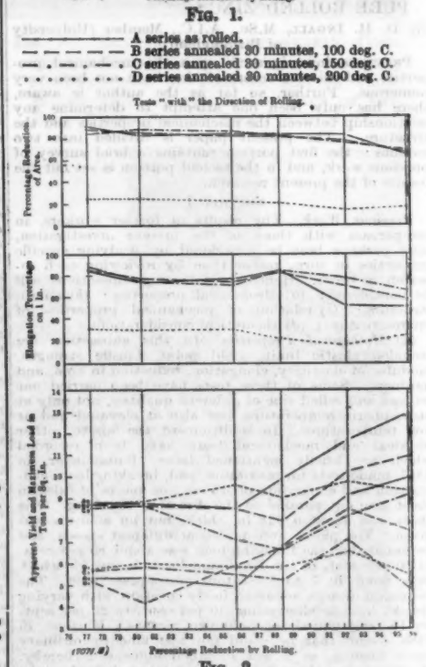

A series as rolled.
B series annealed 30 minutes, 100 deg. C.
C series annealed 30 minutes, 150 deg. C.
D series annealed 30 minutes, 200 deg. C.
Tests "with" the Direction of Rolling.
Percentage Reduction of Area.
Elongation Percentage on 2 in.
Apparent Yield and Maximum Load in Tons per Sq. in.
Percentage Reduction by Rolling.

FIG. 2.

A series { A_1, Apparent yield; A_2, Maximum load } as rolled.
B series { B_1, Apparent yield; B_2, Maximum load } annealed 30 min., 100 deg. C.
C series { C_1, Apparent yield; C_2, Maximum load } annealed 30 min., 150 deg. C.
D series { D_1, Apparent yield; D_2, Maximum load } annealed 30 min., 200 deg. C.

Scleroscope.—The scleroscope hardness was determined, using the ordinary instrument and the normal hammer. A large number of readings were taken to obtain an average, and for comparison the same specimens were used for the scleroscope hardness determinations as were used for the Brinell hardness tests.

The results are plotted against the percentage reduction by rolling in Fig. 1.

Yield and Tensile Strength, Elongation and Reduction of Area.—For the cast metal two specimens were tested which had been cut out of the ingot. The mean values for yield and tensile strength are given in the paper, but no values for elongation or reduction of area could be

obtained as the metal was very coarsely crystalline and parted along grain boundaries with a loud "cry," leaving a jagged fracture which made measurements impossible.

The percentage elongation (on 1 in.) and the reduction of area were certainly not more than 5 per cent., and the exceedingly coarse nature of the material is shown in Fig. 4.

In the case of the rolled metal, six test-pieces, prepared as described in the appendix, were used per sheet per series. Of the six three were "with" and three were "across" the direction of rolling.

The yield strength was obtained by having the points

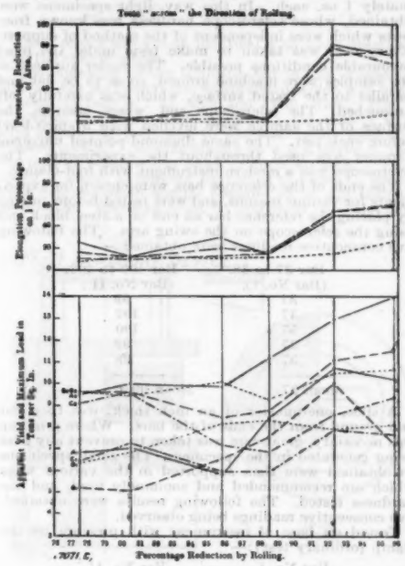

Tests "across" the Direction of Rolling.
Percentage Reduction of Area.
Elongation Percentage on 1 in.
Apparent Yield and Maximum Load in Tons per Sq. In.
Percentage Reduction by Rolling.

FIG. 3.

——— A series	A_1, Apparent yield	as rolled.	
	A_2, Maximum load		
– – – – – B series	B_1, Apparent yield	annealed 30 min., 100 deg. C.	
	B_2, Maximum load		
— · — · — C series	C_1, Apparent yield	annealed 30 min., 150 deg. C.	
	C_2, Maximum load		
· · · · · · · D series	D_1, Apparent yield	annealed 30 min., 200 deg. C.	
	D_2, Maximum load		

of a divider in centre punch marks 1 in. apart during the increase of the load and noting the load at which the divider failed to feel both marks. As this test for yield is only approximate, the results have been designated as apparent yield.

The tensile strength figures were obtained in the normal manner, and have been plotted in the curves under the heading of maximum load.

The rate of loading was greater than usual, about 0·75 minute to 1 minute, being a rough average time from application of load until fracture. This increase of normal rate was adopted to indicate, as far as possible, whether the nature of the metal was ductile or brittle.

The results are plotted against the percentage reduction by rolling as follows:

Apparent yield and maximum load in tons per square inch "with" the direction of rolling; elongation per cent. on 1 in. and reduction of area per cent. "with" the direction of rolling (Fig. 2 on opposite page). Apparent yield and maximum load in tons per square inch "across" the direction of rolling; elongation per cent. on 1 in. and reduction of area per cent. "across" the direction of rolling (Fig. 3 above).

The microstructure of the material is shown in Figs. 4 to 9; Fig. 4 is taken from the cast material; Figs. 5 to 8 are representative of sheets of 2, 4, 5 and 6 in series A, B and C, and Fig. 9 shows the nature of the material in series D. A note on the preparation of specimens for micro-examination is given in the Appendix.

Results of Experiments.—From a careful observation of the material while under test, and from the nature of the results obtained, especially the figures for elongation and reduction of area, the author wishes to state clearly that the curves do not represent absolute values for the material. The reason for this is that the rolled metal has no absolute values for mechanical and other properties, being in itself variable. One variable, clearly brought out by the micro-examination, was grain size, which varied very much in each specimen. There are probably other variables as well, and the author confirms Bauschinger's opinion that the elongation varies from unknown circumstances, also the opinions of Martens and Moore, that rolled zinc possesses a high degree of plasticity and no true elastic limit. When under test the material was found to stretch over the whole of its length, and sometimes when fracture took place the metal "tore apart," the tear sometimes starting from one side and working across to the other, or sometimes starting in the middle and propagating itself to each side simultaneously. For these reason and others, such as flaws, &c., some of the results have been ignored, though three tests were made in each case. However, though the values given cannot be taken as absolute, it is believed that they truly indicate the relative average values of the material and its nature. An examination of the curves, fractures and microstructure in the light of the above remarks reveals the following:—

1. With the material "as rolled" and also when annealed for half an hour at either 100 deg. C. or 150 deg. C.:—(*a*) The hardness (Brinell and sclerosoope) and also the strength (apparent yield and maximum load both "with" and "across" the direction of rolling) show a marked increase in the neighbourhood of 86 per cent. reduction by rolling. (*b*) The opinion of Moore and others that rolled zinc is stronger "across" than "with" the direction of rolling is confirmed. (*c*) That up to about 88 per cent. reduction by rolling the ductility of rolled zinc (as measured by the percentage elongation on 1 in. and the reduction of area) is high "with" and poor "across" the direction of rolling. (*d*) The marked difference of ductility indicated in (*c*) begins to disappear beyond about 88 per cent. reduction (by a slight fall "with" and a rapid rise "across"), until at about 96 per cent. reduction the material is quite ductile in either direction. (*e*) The change in properties occurring at about 86 per cent. to 88 per cent. reduction, mentioned in paragraphs (*a*), (*c*) and (*d*), is not constant and shows a falling off in intensity after about 93 per cent. reduction. The author does not consider that the thinness of the last sheet (0·069 in.) is sufficient to account for this, for which no explanation is offered.

2. With the material annealed for half an hour at 150 deg. C.:—The tensile strength curves both "with" and "across" the direction of rolling seem to indicate that 150 deg. C. is a critical temperature for about 86 per cent. to 88 per cent. reduction by rolling; however, very little support is given by the microstructure where the grain size is only slightly larger on the whole than in the corresponding material for series A and C.

3. With the material annealed for half an hour at 200 deg. C.:—The changes in properties of hardness and strength mentioned in 1 (*a*) are removed and all ductility is destroyed.

4. The microstructure of the material in all the four series was both unexpected and instructive. Owing to the great difference of ductility in the thicker sheets when tested "with" or "across" the direction of rolling in series A, B and C, it was thought that these sheets would probably show signs of cold-work and a "grain" due to elongated crystal grains by rolling. The microstructure revealed in every case an equi-axed crystalline structure with no "grain," though the thinnest sheet showed some signs of work. For this reason the tests have been described as "with" or "across" the direction of rolling and not "with" or

FIG. 4.

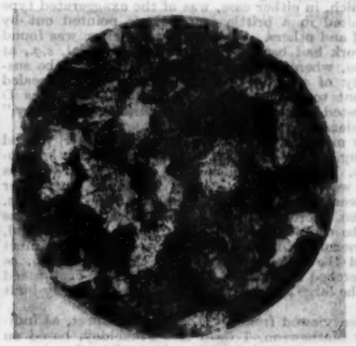


FIG. 5.

FIG. 6.

FIG. 7.

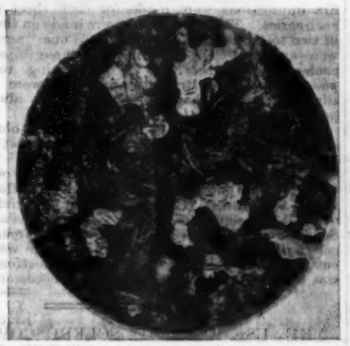


FIG. 8.

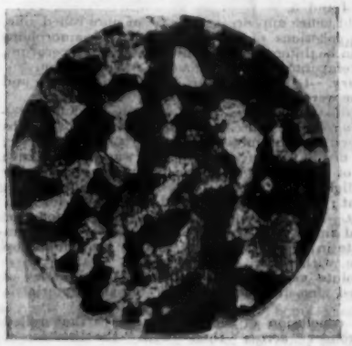


FIG. 9.

FIG. 4. CAST ZINC. MAGNIFICATION 20 DIAMETERS. FIG. 5. CHARACTERISTIC STRUCTURE OF SHEET 2 IN SERIES A, B, AND C. FIGS. 6, 7, AND 8 ARE TYPICAL OF SHEETS 4, 5 AND 6 IN SERIES A, B AND C. FIG. 9 IS THE TYPICAL STRUCTURE OF THE MATERIAL IN SERIES D. ALL ETCHED WITH POTASSIUM BICHROMATE AND NITRIC ACID SOLUTION, AND FIGS. 5, 6, 7, 8, AND 9 MAGNIFIED 50 DIAMETERS.

"across" the grain, as the material has no grain. The structure of the material was quite constant, whether examined on the surface of the sheet or by means of a section through the sheet in the direction of rolling.

5. The crystal grain size, though variable, showed on average that it varied inversely as the reduction in series A, B and C. This would partly be expected owing to the thicker samples of sheet leaving the rolls at a higher temperature and having less work done upon them. The variation of average grain size between each sheet was approximately constant throughout each series A, B and C.

6. Annealing at 200 deg. C. for half an hour (series D) caused either a re-growth or an increased growth of grain which, in either case, was of the exaggerated type and resulted in a brittle material, as pointed out by Timoféef and others. The coarsest structure was found where work had been done upon the material, *e.g.*, at the edges, where it had been cut, confirming the susceptibility of zinc to recrystallisation when annealed subsequent to deformation. The material of series D when tested always gave the characteristic "cry" when under test.

7. The microstructre of the cast zinc (Fig. 4) proved interesting, as it revealed the presence of a macro-structure. In the specimen the large grain surfaces exposed were of the order of ¼ in. across, and after etching were easily and clearly seen with the naked eye. Under the microscope each of these large grains was seen to be composed of small grains which, in general, were abnormally regular in outline, and which must have had the same orientation as the large grain, as they all etched to an equal extent to give an even-toned etch to the large grain, which they had apparently built up.

8. When viewed from the theoretical aspect, as indicated by Mathewson, Trewin and Finkeldey, based on Jeffries' conclusions, the results obtained in the present research present an anomaly. The author is fully aware of the danger of drawing conclusions on insufficient data, and realises the need of far more research to elucidate the true facts. With this reservation the anomaly may be indicated as follows:—In series A, B and C the metal of sheets 3, 4 and 5 showed a similar equi-axed grain structure. This would be interpreted that the metal when being rolled at a temperature of not less than 150 deg. C. was either at or above the equi-cohesive temperature. Though the average grain size of sheet 4 was a little less than that of sheet 3, and, similarly, the average grain size of sheet 5 was a little less than that of sheet 4, the difference in each case was approximately the same. As the metal was rolled at or above the equi-cohesive temperature, the tests in the cold state would indicate one of the following:—(*a*) If the testing were carried out below the equi-cohesive temperature, the difference of mechanical properties in sheets 3, 4 and 5 should be approximately the same as the difference of average grain size was approximately the same. (*b*) If the testing were carried out at the equi-cohesive temperature the mechanical properties should be constant for sheets 3, 4 and 5.

The actual results show that while there is very little difference between the mechanical properties of sheets 3 and 4, there is a very marked difference between those of sheets 4 and 5.

It would hence appear, in the case of pure rolled zinc, that the cohesions of the crystalline and amorphous phases can be different at the equi-cohesive temperature, *i.e.*, the temperature of spontaneous crystallisation.

Summary.—1. The polishing and etching of cast and rolled zinc were investigated.

The most successful results were obtained as follows:—

Polishing.—The lightest possible pressure on cloths and papers; Globe metal polish on chamois leather; removal of maximum grease with water-free ether; removal of last traces of grease and fine scratches by rubbing lightly on a thin paste of magnesia on wet parchment; washing in water and *keeping wet* for:

Etching.—The most successful reagent tried for cast and rolled zinc was a 2 per cent. solution of potassium bichromate in 50 per cent. nitric acid; 1 c.c. made up to 200 c.c. with water.

2. Absolute values for the mechanical properties of pure rolled zinc are not obtainable as the material is variable.

3. The conclusion of Moore and others that rolled zinc is stronger "across" than "with" the direction of rolling is corroborated.

Pure rolled zinc with a reduction by rolling of 77 per cent. to about 86 per cent. has a tensile strength of about 6 tons per sq. in., which rises to about 13½ tons per sq. in. with 96 per cent. reduction by rolling.

4. The ductility of pure rolled zinc with 77 per cent. to about 88 per cent. reduction by rolling as measured by the percentage elongation on 1 in. and the reduction of area is found to be good (about 80 per cent.) when tested "with," and poor (about 20 per cent.) when tested "across" the direction of rolling. Beyond 88 per cent. reduction the ductility "across" rises sharply until the material is quite ductile in either direction with 96 per cent. reduction by rolling.

5. Annealing for half an hour at either 100 deg. C. or 150 deg. C. has little effect on (3) or (4), though it would appear that 150 deg. C. is a critical temperature for about 86 per cent. to 88 per cent. reduction by rolling.

6. The micro-examination of pure rolled zinc from 77 per cent. to 96 per cent. reduction by rolling reveals an equi-axed structure. It would appear that at the temperature of rolling recrystallisation opposes the strain hardening of rolling. This opposition predominates up to about 86 to 88 per cent. reduction by rolling, after which the strain hardening develops rapidly, although it is completely concealed by the microstructure.

7. Annealing for half an hour at 200 deg. C. renders pure rolled zinc weak and brittle, due to coarse crystallisation of the exaggerated kind, as pointed out by Timoféef and others.

In conclusion, the author desires to express his sincere thanks to Professor T. Turner for his suggestion, kind interest and advice in the present work; to his colleague H. Harris for interest and assistance with the analyses; to Professor F. C. Lea and R. E. Stradling (Department of Civil Engineering) for every facility and help in the mechanical testing, and last, but not least, to Messrs. London Zinc Mills, Limited, for their kindness in providing the rolled zinc used.

APPENDIX.

Test Pieces.—The six sheets of rolled zinc obtained measured approximately 6 in. by 24 in. From the sheets were cut strips measuring 6 in. by ½ in., both "with" and "across" the direction of rolling. The strips were then planed in bunches in a planing machine to give a central reduced portion of approximate dimensions 2 in. by ½ in., leaving 2 in. shoulders on each side. In the case of series B, C and D, the strips were annealed before planing, so as to avoid the possibility of any irregularities due to initial cold work. The strips were stamped at each end, as marked out on the original sheets, before any cutting up, planing, or annealing was done, to distinctly identify them. In the case of the rolled metal, six test pieces were used per sheet in series. Of the six, three were "with" and three were "across" the direction of rolling. The three similar specimens were marked *a*, *b* and *c* with ink on one shoulder for identification. Each specimen was marked out with ¼ in. cross scratches across the reduced portion for measuring the percentage elongation on 1 in., and also the reduced portion was measured with a micrometer in three places (one central and one half-way between the centre and each shoulder), starting in each case from the ink mark, so that the original area at the place of fracture was accurately known for finding the reduction of area. The cross-sectional area after break was measured at the edges of the fracture with a micrometer in the usual way.

NOTES ON HARDNESS TESTS.

Brinell.—Preliminary investigations with an ordinary multi-lever Brinell machine showed that a load of 500 kilos. was far too much and made an impression right through No. 4 sheet. It was not possible to adapt this machine to much lower loads, so a simple single-lever concrete testing machine was modified for the purpose. This was arranged to give a load of 200 kilos., which was found by trial to be the most suitable. The duration of the load was one minute in each case.

The results were calculated from the accepted formula:

$$\text{Brinell number} = \frac{P}{2\pi r\left(r - \sqrt{r^2 - \frac{D^2}{4}}\right)}$$

Where r = radius of the ball in mm.
d = diameter of the impression in mm.
P = total pressure in kilos.

Six impressions were made for each sheet number in each series. The impressions were made on the shoulders of two test pieces (one "with" and one "across"), and were arranged so that there were three impressions on each side of the sheet. It is interesting to note in passing that the Brinell impressions were invariably slightly oval in shape, the major axis always being parallel to the direction of rolling.

Scleroscope.—Owing to the variation obtained, at least a dozen readings were taken in each test to give an average value.

Specimens for Micro-examination.—The original intention was to cut the micro-specimens from the shoulders of the test pieces. However, as the material stretched over all its length when under test, this was abandoned. Separate specimens were cut which were treated identically with the test specimens. Great care was taken to cut the micro-specimens so that the direction of rolling was known, but this proved to be unnecessary.

THE USE OF THE SCLEROSCOPE ON LIGHT SPECIMENS OF METALS.*

By FRED S. TRITTON, Member (from the National Physical Laboratory, Teddington).

SOME experience in the use of the scleroscope for testing the hardness of small pieces of metal in the laboratory led the author to doubt whether the real hardness value of small samples were obtained, although the usual precautions were taken to support the specimens in an apparently rigid manner. The experiments were undertaken with the view of finding out whether errors existed when using the ordinary methods of support and, if so, to find some method of support that would eliminate them.

The book of instructions issued by the Shore Instrument Company shows that the importance of proper support of light samples is well recognised as essential if correct values are to be obtained. It also states that the specimen must be in the form of a cube weighing at least 1 lb. before its inertia is large enough to resist the kinetic force of the falling hammer sufficiently to render the height of rebound independent of the mode of support.

The present experiments show that hardness tests on underweight samples, carried out in the usual ways that are recommended, do not give results with the accuracy of which the instrument is capable.

As scleroscope hardness tests made on under-weight specimens have recently been used in scientific papers, the author desires, by the present preliminary paper, to show that caution should be used in placing reliance on the results of such tests. For the first experiment, two standard hardness reference bars, each weighing 14 oz., were selected, having a hardness of 37 to 38 and 100 to 102 respectively. Marked areas of the surfaces were first tested in the ordinary way, and small pieces, which included the tested areas, were afterwards cut or ground from the block. The size of the pieces cut out was 1 in. by 1 in. by ¼ in., and their weight approximately 1 oz. each. In this way, light specimens were obtained, whose scleroscope hardness was known from tests which were independent of the method of support. Every care was taken to make tests under the most favourable conditions possible. The under surfaces of the samples were machine ground, so as to be flat and parallel to the tested surface, which was carefully left untouched. The scleroscope and, where possible, the surface of the sample were levelled with a spirit-level before each test. The same diamond-pointed universal hammer was used throughout the experiments. The scleroscope was a modern instrument with foot-clamp.

The ends of the reference bars were chosen for experiments for various reasons, and were tested before cutting by placing the reference bar on end on a steel block and using the scleroscope on the swing arm. The following five consecutive readings were obtained:—

Bar 37 to 38. (Bar No. 1).	Bar 100 to 102. (Bar No. II.)
37	99
37	102
37	100
37	99
37	98
Mean 37	Mean 99·6

A slice, one-quarter of an inch thick, was then cut and ground from the ends of the bars. Where grinding was necessary, great care was taken to prevent any heat being generated in the specimen. The small specimens so obtained were then supported in the various ways which are recommended and commonly used, and the hardness tested. The following results were obtained, five consecutive readings being observed.

Tested on base of instrument with pressure on the clamp (ordinary test):—

Bar No. I.	Bar No. II.
32	81
33	75
33	79
33	83
32	84
Mean 32·6	Mean 80·6

As compared with true value:—

37 to 38	100 to 102

Specimens gripped in a vice with steel jaws. Tests were made in a straight line across the specimen, the first and last readings being close to the jaws of the vice:—

Bar No. I.	Bar No. II.
29	67
28	63
26	60
29	65
30	70
Mean 28·4	Mean 65

In vice, using copper grips:—

Bar No. I.	Bar No. II.
32	76
32	75
29	70
29	73
31	75
Mean 30·6	Mean 73·8

Pressed into plaster mount, maintaining a pressure on the clamp:—

Bar No. I.	Bar No. II.
30	82
29	65
27	78
28	76
31	60
Mean 29	Mean 72·2

It will be seen that none of the ordinary methods of support gave results as high as those obtained from the bar before cutting, the greatest errors being found in the tests on the hard steel specimen. Other means of support were therefore tried, the procedure of the first successful method being as follows:—

A small piece of pitch taken from the plaster mould is softened by holding in the fingers for a few moments; this is then applied to the bottom of the specimen to be tested. The sample and pitch are then placed in a screw clamp, such as that provided with the old pattern scleroscope, and screwed up slowly, allowing the pitch to flow from under the specimen until only a thin film remains; at this point further screwing becomes difficult and the sample is ready for test. Samples tested with this support gave values equal to those obtained from the reference bar. There were, however, objections to the use of this type of clamp, one being that only a small area could be tested without moving the specimen; also that, owing to the rotation of the screw on the pitch,

* Paper read before the Institute of Metals at the Birmingham Meeting, September 22, 1921.

it was difficult to keep the sample in exactly the place required for testing.

A new type of clamp was, therefore, designed by Dr. W. Rosenhain, which eliminated these difficulties. Using this clamp with a layer of pitch beneath the specimens, the following results were obtained with the previous samples:—

Bar No. I.	Bar No. II.
37·5	98
37	99
37·5	99
37	100
37	99
Mean 37·2	Mean 99

These results are almost identical with those obtained from the reference bars.

This clamping device is illustrated in Fig. 1 and in Fig. 3; the maximum size of specimen which it is constructed to take is 1 in. high and 1¼ in. wide. Fig. 1 illustrates the clamp fully extended; the base A is a solid cylinder of tool steel, to which is rigidly fixed the screwed part A1. Sliding closely on A is a sleeve B, the top part of which is cut away to form an arch. This sleeve is raised or lowered by means of screw C, which when screwed down applies pressure to B, and thus to the sample. Screwing must be continued until the film

Fig. 1. CLAMPING DEVICE.

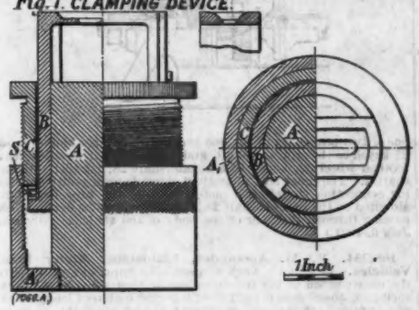
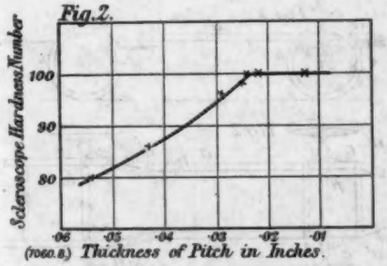


Fig. 2.



of pitch under the specimen is not more than 0·024 of an inch thick, otherwise correct results will not be obtained. The flow of the pitch is very slow at this stage, and considerable pressure is required to cause further movement to take place at all quickly. The sample is now ready for test, the portion available for this purpose being that exposed by the slot in the top of the arch. This slot permits a line of tests to be made across the full width of the sample, and is broad enough to allow two tests to be made side by side. The original design for the clamp, which is shown in Fig. 1, has a strong spring (S) between the screwed part C and the foot of the sleeve B. It was hoped that by means of this spring a constant pressure could be kept on the sample, so that it would only be necessary to place the specimen and pitch in the clamp and screw up C until the spring was fully compressed, and the pressure of the spring would then slowly compress the pitch until the required thickness was obtained. It was found, however, that the interposition of this spring affects the rebounds of the hammer, and it has not been used in any of the experiments described in this paper, the pitch having to be compressed by constant hand pressure on the screw. The time taken to prepare the sample for test is about five to ten minutes, according to the size of the specimen and the amount of pitch. It is hoped that some form of spring may be found suitable, as the time taken in mounting the specimen by the present method is a disadvantage. The use of a pitch of low viscosity was found to be very messy and inconvenient.

The effect of varying the thickness of pitch beneath the specimen is shown in Fig. 2, the real hardness number of the sample being 100 to 102. In this experiment, a thick piece of pitch was placed beneath the specimen and compressed slowly in the screw clamp. Scleroscope tests were made at intervals during the compression, the thickness of the layer of pitch being measured by means of "feeler" gauges, which were used between the top of the steel support and the bottom of the specimen, one side of which was left free from pitch.

The necessity of having a layer of pitch less than 0·025 of an inch thick, in order to obtain correct rebounds, led the author to experiment with other viscous substances, with the idea that perhaps the rigidity of the film alone might be sufficient to hold the specimen without the use of any clamp, thus leaving the whole surface of the sample free for testing purposes. Adhesive substances were first tried, the samples being attached to a hard steel block by means of various substances, such as Canada balsam, spirit gum, cellulose acetate dope, &c. These were allowed to dry or set, but, although good results were obtained with them, it was found that the time necessary for the material to set was too long for practical use. Attention was, therefore, turned to substances of high viscosity which would not set. A solution of glucose considerably stiffer than treacle was found to give excellent results. Using the previous samples attached by means of glucose to a hard steel base, the following results were obtained:—

Bar No. I.	Bar No. II.
37	99
37·5	97
37	99
	99

The manipulation is very simple and quick. The bottom of the specimen, which must be fairly flat, is smeared with glucose and pressed or wrung with a sliding action on to a flat-topped steel base, weighing at least 1 lb. The whole surface of the specimen is then

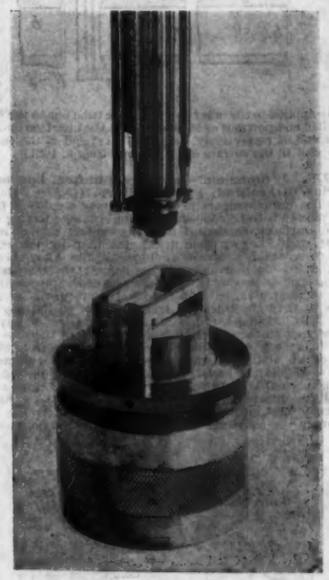


FIG. 3.

Metal.	Scleroscope Hardness.
Hardness tool steel	95 to 100
Normalised tool steel	35 to 36
Aluminium ...	about 4
Lead	2 to 4

For these tests fresh specimens, having the same dimensions as the last, were obtained. The scleroscope hardness of the marked areas of the samples before cutting was 97 to 100 and 37 to 38.

The results of tests on these specimens, when attached with glucose to supports of various metals, are shown in the table. Three consecutive rebounds were observed.

	Specimen 37 to 38.	Specimen 97 to 100.
Cast lead support	35	82
	35	91
	34	91
Cast aluminium	37	96
	37	96
	38	94
Normalised tool steel ...	37	98
	36	97
	37	99
Hardened tool steel ...	37	98
	37·5	98
	37	98

The results show that the rebound of the hammer is

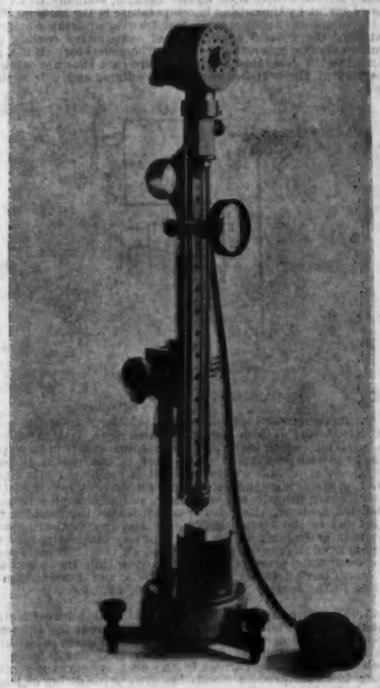


FIG. 4.

perfectly supported for testing purposes. It is necessary to see that no air bubbles are trapped in the glucose beneath the specimen. The formation of these may be easily avoided by sliding the specimen about in all directions on the support, until only a very thin layer of clear glucose remains. Fresh glucose should continually be used, especially in dry weather. The use of stainless steel for the supports suggests itself, as they could be cleaned from glucose by leaving them in water without fear of rust. The scleroscope can be used on the swing arm, but the old pattern stand is more steady.

Fig. 4, above, shows the scleroscope fitted to the old pattern stand, with a specimen mounted with glucose on a hard steel cylinder ready for test. This arrangement was found to be most convenient.

The great disadvantage of the glucose method of supporting the specimen is the danger of getting glucose on the hammer or the surface under test. This danger is reduced to a minimum if the specimens are mounted on a separate base, as illustrated. The preparation and removal of samples and their supports can then be done apart from the scleroscope, and there is little chance of the glucose getting where it should not be. The glucose can be removed from the specimen and support in a few minutes with water and, although there are doubtless other substances that would do as well as glucose, there are many advantages in using this common substance. The glucose used in these experiments was the ordinary liquid commercial variety having a specific gravity of 1·425. Where testing is only carried on intermittently, the glucose can with advantage be kept in an ordinary collapsible metal tube.

Another probable source of error that was suspected in the scleroscope test, is that the elasticity of the material supporting the specimen might affect the rebound of the hammer, and in order to investigate this a number of metal bases were obtained whose scleroscope hardness and density were very different. They were made in the form of cylinders whose diameter and height were equal. Each cylinder weighed 1 lb., and the metals used are enumerated in the table which follows.

slightly affected by using metals to support the specimens, even when the specimen is a quarter of an inch thick. Some experiments have been made with samples of metals 0·05 in. thick, but the results showed that the problem of testing thin sheet is very complex, and much further work would be necessary before the results could be understood, one peculiar point being that higher rebounds were consistently obtained when using the lead support than when using any of the other metals, thus completely reversing the order obtained with the thicker specimens.

In connection with the scleroscope hardness test on very thin sheet, the anvil effect has been investigated by G. H. Bienkarn, and the results described in a paper read at a meeting of the Birmingham Local Section of the Institute of Metals held on November 16, 1920. The use of oil, placed between the layers of metal to be tested, was also mentioned by Redding in the discussion of Bienkarn's paper. The difference in the readings obtained by varying the thickness and surface conditions of the specimen have also been investigated by J. Neill Greenwood.

In conclusion, the results of the experiments show that the usual methods of supporting light specimens of metal for the scleroscope test do not give results with the accuracy which can be obtained when the specimens are supported by the methods that have been described. The first method is only applicable to specimens having two flat parallel surfaces, but the second method could be applied to specimens having curved surfaces, such as balls or rollers, providing that a recessed support is made to fit them.

The author wishes to acknowledge his indebtedness to the staff of the Metrology Department workshop for their skilled assistance in grinding the hard steel specimens, and to Dr. W. Rosenhain, F.R.S., for the assistance and interest he has taken in this work.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

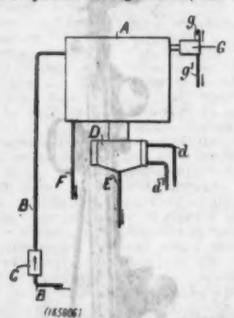
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

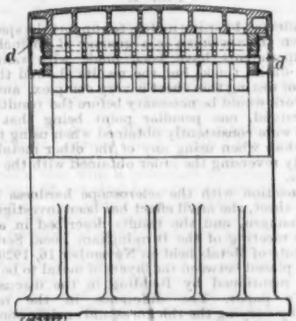
ELECTRICAL APPARATUS.

165,806. Vickers, Limited, Westminster, and A. B. Field, Westminster. Cooling Dynamo Electric Machines. (7 *Figs.*) June 19, 1918.—The cooling of dynamo electric machines is effected, according to this invention, by employing an evaporable cooling medium which is circulated or passed through passages formed or provided in the machines, and/or is sprayed upon the parts to be cooled in such manner that the cooling is effected mainly by the evaporation of the medium, and only to an incidental extent by the raising in temperature of the medium either in the liquid or vapour state. The drawing illustrates diagrammatically the general application of evaporative cooling to a dynamo electric generator. A is a turbo generator. B is a pipe leading to the generator A from a sump (not shown) containing a supply of the evaporable cooling medium, and C is a pump



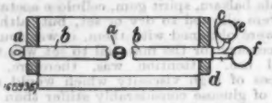
for withdrawing the medium in its liquid form from the sump and introducing it into the turbo-generator. D is a surface condenser into which the evaporated medium enters in its vaporised or partially-vaporised state after it has passed through the generator A, and within which it is condensed into liquid form. *d*, *d*1 are inlet and outlet pipes respectively for circulating cooling water through the condenser, and E is a pipe through which the medium, after condensation, leaves the condenser D on its way to the sump. F is a pipe also communicating with the sump for draining off the surplus or unvolatilised part of the medium from the generator A. G is an air pump for use when a sub-atmospheric pressure is maintained within the generator, the pump having an air discharge pipe *g*, and a connection *g*1 leading to the sump. (*Accepted July* 20, 1921.)

165,937. G. Schroeder, Hale. Cooling Dynamo-Electric Machinery. (5 *Figs.*) April 1, 1920.—To prevent the difference of potential produced between the two ends of ducts constituted in the core and through which cooling fluid flows, becoming effective in producing current in the duct system, the cooling arrangement comprises a circulating system consisting of longitudinal tubular parts in the core, which lie across the path of



movement of the flux and inter-connecting parts *d* at the ends of the core. The longitudinal and end parts are formed of, or provided with, portions or insertion pieces of non-conducting or very poorly conducting material, so that there is no closed metallic circuit in the system for the flow of currents due to electro-motive forces resulting from the flux movements in the core. (*Accepted July* 20, 1921.)

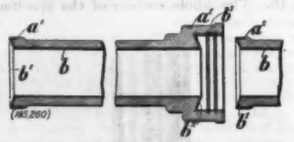
165,936. G. Schroeder, Hale. Cooling Dynamo Electric Machinery. (5 *Figs.*) April 1, 1920.—In cooling systems for dynamo electric machinery in which cooling is effected by means of liquid flowing through ducts in the core which are disposed across the path of movement of the lines of flux, the tubes which form the cooling system are disposed and inter-connected in such a way that the sum of the electro-motive forces generated by the flux cutting the tubes is approximately zero in any complete circuit formed by the tubes. A way of producing a non-inductive arrangement of cooling tubes, is to employ as the element of the circulating system a pair of tubes, one of which is used for the outward flow and the other for the return, these two tubes being located in the core in such positions that practically the same flux or equal fluxes cut through both tubes of a pair in the same way at the same time. The pairing of the tubes is brought about by placing the two members of a pair close together preferably within the same longitudinal duct in the core. In the example illustrated, the duct is circular and a thin-walled tube *a* of semi-circular section is bent on itself so



that the flat sides lie together. The folded tube is inserted in the duct, insulation being interposed at *b*. The free ends *e*, *d* of the tube are connected with chambers *e*, *f*, forming the inlet and outlet connections respectively. A pair of chambers *e*, *f*, may be provided at each end of the core, and between each pair of chambers the liquid will pass along a series of ducts through the core and back again to the same end. (*Accepted July* 20, 1921.)

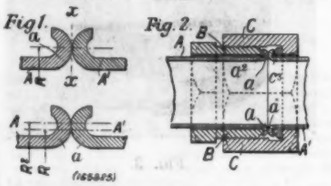
HYDRAULIC MACHINERY.

165,260. C. Thomas, Thomas Town, Tonyrefail. Pipes or Tubes. (1 *Fig.*) April 13, 1920.—Water pipes with butted joints in which corrosion is obviated by an internal lining of enamel, have, according to this invention, the lining *b* of enamel



not only applied to the inner portion of the tube but to the butting or bevelled end portions as at b^1 and b^2, on the insertion and socket ends a^1 and a^2 respectively. At the socket end a^2 the enamel is also applied to the surface b^3. (*Accepted July* 6, 1921.)

165,925. J. Stone and Company, Limited, London, and F. Davies, Birkenhead. Pipe Couplings. (15 *Figs.*) March 27, 1920.—The improvements in pipe couplings consist in forming on the pipe ends to be connected facsimile flanges having convex abutting surfaces, so shaped that the contact surface between pairs of such flanges, when drawn together by the coupling flanges or unions, is a narrow annulus. A and A1 are the pipes to be coupled together and *a* is the flange; the section of the flange on a plane passing through the axis of the pipe is approximately semi-circular, but the radius of curvature is preferably such as to vary the thickness from the root to the top of the flange. The thickness of the flange should not at any point from the root to the crown be less than that of the pipe; preferably it is made to increase slightly in thickness from the root to the crown or line of contact, which is a circle of radius R (Fig. 1.) Should the surface at the radius R not quite coincide with the normal transverse plane *x x*, there will be, as a result of axial pressure in jointing, a slight compression of the parts which come first into contact, and when the flanges are drawn together by the coupling, the abutting convex surfaces will be



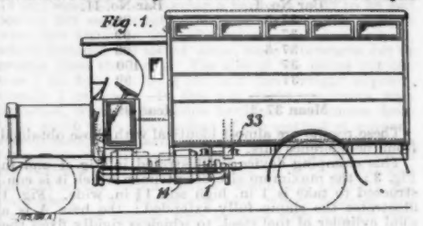
slightly flattened so that the contact surface becomes an annulus having an internal radius R and an external radius R^2 (see lower Fig. 1 where for clearness the flattening is exaggerated). Obviously, the more accurately the flanges are turned over so as to be normal and facsimiles the less will the degree of flattening require to be in order to obtain the necessary contact all round to ensure fluid-tightness; preferably, the annulus should be as narrow as possible, so that the contact pressures per unit of surface may be a maximum for a given tightening axial pressure. Before the ends of the pipes to be connected are flanged, an externally screwed union B (see Fig. 2) is threaded over the one and an internally-threaded union C is threaded over the other and the joint is made by screwing these two unions together, as shown in Fig. 2. The union C has an internal flange which may be made to fit the concave side of the pipe flange *a* of the pipe A1; preferably, however, a loose extension c^3 of the flange fits the concave back of pipe flange so that the part bearing against the back of the flange need not turn as the union is screwed up. The nose a^2 of the union A may alternatively, and for the same reason, be made to fit the concave back of the flange *a* of the pipe A. (*Accepted July* 20, 1921.)

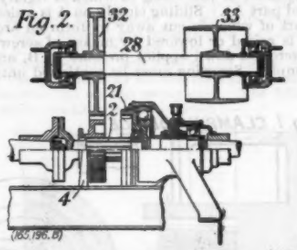
MOTOR ROAD VEHICLES.

165,173. The Coir Tyre Company, Limited, Manchester, and G. D. Rose, Manchester. Steering Wheels. (2 *Figs.*) March 18, 1920.—The rim 3 of the steering wheel of motor cars, or in some cases the whole wheel, is formed of coir fibre either alone or combined with other fibre and impregnated or combined with rubber or other adhesive material submitted to pressure,

and covered or not as desired with vulcanite and finally vulcanised. The boss 1 and spokes 2 are, in most cases, formed of metal. The spokes 2 penetrate the rim 3 to a considerable extent, and the coir fibre material is extended along each of the spokes, as shown, to form sockets 3a in order to strengthen the structure. (*Accepted July* 6, 1921.)

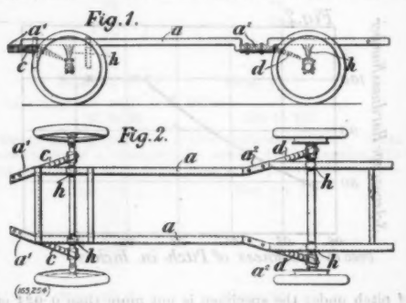
165,196. P. F. Smith, Maidstone, E. H. Dine, Maidstone, and F. R. Stocks, Maidstone. Motor Road Vehicles. (4 *Figs.*) March 20, 1920.—To avoid the necessity of providing an additional and separate motor for driving machine tools in a travelling workshop mounted in a petrol-electric vehicle or van, there is provided, adjacent the rear of the electric motor 14 and between it and the propeller shaft driving the differential gear, a toothed gear wheel 1 movable longitudinally of, and feathered or splined to, an extension 2 of the electric motor shaft. The toothed wheel 1 slides upon the shaft by means of a lever placed adjacent to the driver's seat and connected to a forked lever arm 4 mounted upon a transverse shaft engaging a groove of the sleeve of the sliding toothed wheel 1. The wheel 1 occupies





one of two positions; in the one it engages an inner ring of teeth 21 keyed to the propeller shaft, and in the other it meshes with a toothed wheel 32, keyed to a countershaft 28, parallel with the shaft 2. The inner ring of teeth 21, constitutes a positive clutch for connecting the electric motor shaft to the propeller shaft. Mounted on the counter-shaft 28 is a pulley 33, which drives a belt passing through the floor of the body of the vehicle. (*Accepted July* 6, 1921.)

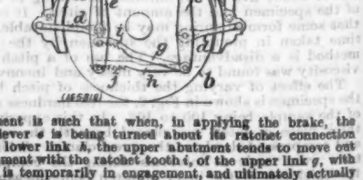
165,254. R. M. Alexander, Maidstone. Motor Road Vehicles. (3 *Figs.*). April 9, 1920.—To improve and simplify the construction of the frames of motor road vehicles and their springing, the chassis is built up of inverted U-shaped longitudinal members *a*, each inclined or inswept at two places *a*1, *a*2 in its length; the thick ends of laminated springs *c*, *d* are bolted within



these inswept inclined portions *a*1, *a*2, their other ends being attached to the front and rear axles, respectively. Acting in conjunction with the laminated leaf springs *c*, *d* are volute or helical springs *h*, arranged between the underside of the frame members *a* and the upper side of the axles. (*Accepted July* 6, 1921.)

RAILWAYS AND TRAMWAYS.

165,819. G. B. Bowles, Forest Gate. Brake Apparatus. (5 *Figs.*) March 5, 1919.—A pair of brake shoes *a* common to one wheel *b* is applied to and released from the wheel through rigging comprising a pendant lever *e*, connected to one brake shoe through a rod *d*, and a similar lever *e* equivalently connected to the other brake shoe, but mounted in a floating manner from a swing link *f*. The lower ends of levers *c*, *e*, are connected to a pair of links *g*, *h*, each having a set of ratchet teeth *i*, *j*, respectively. The ratchet ends of the links *g*, *h*, co-operate with relatively stationary abutments on the floating lever *e*. The abutments are spaced apart so that the portion of the floating lever *e* between them makes a triangle with the connecting links *g*, *h*. The whole



arrangement is such that when, in applying the brake, the floating lever *e* is being turned about its ratchet connection with the lower link *h*, the upper abutment tends to move out of engagement with the ratchet tooth *i*, of the upper link *g*, with which it is temporarily in engagement, and ultimately actually leaves this tooth and engages the next in order, when sufficient angular displacement occurs, due to wear. With return movement of the rigging upon release of the brake, the floating lever *e* rotates about the ratchet connection with the upper link *g*, and hence there is disengagement of the lower abutment from the ratchet tooth *j* of the lower link *h*, and its re-engagement with the tooth *j* next in order, thereby taking up the slack due to wear. (*Accepted July* 20, 1921.)